MEMORANDUM

910601.0141

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TO: Honorable Mayor and
Members of City Council

Members of the Environmental
Quality Advisory Committee

FROM: M. Lyle Lacy, III
City Manager

DATE: June 27, 1985

SUBJECT: HISTORIC URANIUM RELEASE REPORT - OAK RIDGE FACILITIES

You will find attached information that has been provided by the Department of Energy on uranium releases from the Oak Ridge facilities since the 1940's. The information is detailed by facility and separated by air and water releases and ground burial. A front page article from the Knoxville Journal also accompanies the report.

I am asking that EQAB review this material at its next meeting on Thursday, July 11, 1985 and provide guidance to Council and staff on the criticalness of the releases and burial from an environmental standpoint, and to identify follow-up questions for the City to pursue with DOE.

M. Lyle Lacy, III

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Attachment

REPORT ON HISTORIC URANIUM RELEASES FROM CURRENT DOE, OAK RIDGE OPERATIONS OFFICE FACILITIES

June 24, 1985

REPORT ON HISTORIC URANIUM RELEASES FROM CURRENT DOE, OAK RIDGE OPERATIONS OFFICE FACILITIES

INTRODUCTION

Since 1947 large quantities of uranium have been processed in production facilities that support the overall mission of the Department of Energy, Oak Ridge Operations (DOE/ORO). The principal programs under DOE/ORO that involve the processing of uranium are:

1. Production of enriched uranium for fueling nuclear powerplants in the United States and abroad.
2. Production of nuclear weapons components in support of National defense programs.
3. Processing of uranium feed materials and related production of uranium fuel cores for U. S. plutonium production reactors.

These activities are accomplished through the efforts of staff located at six DOE/ORO plants. Three of these plants are gaseous diffusion plants involved in the enrichment of uranium fuel. The Y-12 Plant is a metallurgical and machining facility for the production of nuclear weapons components. The Feed Materials Production Center (FMPC) and the RMI Extrusion Plant each perform different steps in the processing of uranium feed materials. A seventh DOE/ORO facility, Oak Ridge National Laboratory (ORNL), has handled relatively small quantities of uranium in nuclear research and development programs.

All of these facilities, in handling and processing uranium, have released

uranium to the environment and have generated varying quantities of uranium waste as a by-product of ongoing operations.

This report discusses radiation dose to the public resulting from the release of uranium only. More detailed data, from which this report was prepared, are available. Future reports will be prepared to address other radionuclides if information on the releases proves to be significant.

MODES OF URANIUM RELEASE

Gaseous Diffusion Plants

The largest single activity under DOE/ORO in terms of both budget and personnel is the production of enriched uranium at the three gaseous diffusion plants. Martin Marietta Energy Systems, Inc., operates the Oak Ridge, Tennessee, and Paducah, Kentucky, plants, and Goodyear Atomic Corporation operates the Portsmouth, Ohio, facility.

Uranium is released to the air through vents in the gaseous diffusion process buildings. Vents release light gases (mostly air) that would otherwise accumulate rapidly at the enriched end of the gaseous diffusion processes and interfere with operations. Releases also occur from buildings in which uranium in one form is converted to another form--for instance, when uranium hexafluoride is converted to uranium tetrafluoride.

The primary source of waterborne uranium at the gaseous diffusion plants is the equipment cleaning process. Liquid effluents are treated to remove uranium and then discharged to streams adjacent to the plants. Wastewater containing enriched uranium is routed through a recovery and recycle process

to remove as much uranium as possible. The uranium that is removed is retained on site and, where feasible, is recycled for further use.

The uranium handling and processing activities at the three gaseous diffusion plants have resulted in burial of uranium-contaminated solid wastes as well as uranium releases to the air and to water. Buried wastes containing uranium generally include:

1. Waste paper, rags, and floor sweepings from general cleanup operations.
2. Wastewater treatment sludges.
3. Residuals, such as filters, trapping media, and scrubber solids from air pollutant control devices.
4. Scrap metals.

Quantities and types of solid wastes generated, and subsequently buried, have varied through the years in relation to fluctuating production levels.

Y-12 Plant

Current activities at the Y-12 Plant, located in Oak Ridge, Tennessee, include:

1. Production of nuclear weapons components.
2. Fabrication assistance to DOE's weapons design laboratories.
3. Source and special nuclear materials processing.

4. Support to ORNL facilities located at the Y-12 Plant.

5. Support to other government agencies.

The production of components for nuclear weapons systems involves the conversion of uranium compounds to metal and the appropriate casting, rolling, forming, and machining operations required to produce a finished product. Assistance to ORNL and other Government agencies generally consists of precision machining and/or assembly of many varied items, most not involving uranium.

Both airborne and waterborne uranium releases from the Y-12 Plant emanate from the uranium metal machining and chemical processing operations. In addition, waterborne uranium includes uranium contained in the runoff caused by natural precipitation onto and around outside storage facilities. This runoff also includes airborne uranium that has been deposited on site. The Y-12 Plant uranium waste streams, like those at the gaseous diffusion plants, are processed through recovery and recycle or treatment before the liquid wastes, containing very small amounts of uranium in solution, are released to nearby streams.

The manufacturing and machining operations at the Y-12 Plant result in solid wastes similar to those produced at the gaseous diffusion plants plus depleted uranium metal turnings from machining operations. After treating wastes to remove depleted uranium or to recover enriched uranium, the remaining uranium-bearing solids have been buried on site in shallow land burial trenches. Solid waste generated at the Y-12 Plant is buried on the plant site. In

the early years of the Y-12 Plant operations, some solid waste was also buried at the ORNL site.

Feed Materials Production Center

Located outside Cincinnati, Ohio, FMPC is involved in the processing of uranium feed materials into uranium metal forms for use in the National defense program and in the production of electricity. At one time FMPC also converted uranium ore and recycle materials to uranium oxide for use at gaseous diffusion plants.

Following initial conversion operations, uranium metal is refined and purified and then cast into metal forms of various sizes and shapes. Depleted uranium metal is shipped to DOE's Y-12 site in Tennessee and Rocky Flats site in Colorado. Other metal forms are center-drilled, surface-machined, and then sent to RMI to be extruded into tubes. Those tubes for use at DOE's Savannah River site in South Carolina are returned to FMPC for final machining to form hollow cores. These fuel cores are used in plutonium production reactors as part of our National defense program.

Airborne uranium releases at FMPC have resulted from many plant operations. At all major release points, however, emission control devices are used to reduce the plant emissions. Radioactive dust generated by manufacturing processes at FMPC are captured by bag-type dust collectors. Collector failures, however, have resulted in large releases of uranium to the air. Liquid effluent releases have originated from the use of water to quench hot uranium metal forms and to clean plant equipment. The plant treats wastewater to remove uranium before it is released to nearby waterways. However, large

releases have, nevertheless, occurred. Information on these releases has been previously disseminated to the public and is summarized in this report.

The production activities at FMPC result in uranium-contaminated solid wastes. Where economically feasible, the uranium in the waste is recovered and recycled back into the process. Where recovery is not feasible, the waste is stored in drums on site, awaiting final off-site disposal. In the past, radioactive solid waste was disposed of on site.

RMI Extrusion Plant

The RMI Extrusion Plant is a privately owned facility located in Ashtabula, Ohio. DOE's involvement at RMI is limited to the operation of a large press and associated support services, which are required for the extrusion and handling of uranium metal. At RMI the uranium metal forms received from FMPC are extruded into tubes. Some of these tubes are returned to FMPC for finishing before being sent to DOE's Savannah River site for use in production reactors. Other uranium tubes are fabricated into final products at RMI and are then shipped to DOE's Richland, Washington, site where they are co-extruded to form fuel elements for DOE's nuclear reactors.

Airborne uranium releases at RMI occur from six plant operations, but the two primary release points are an abrasive saw and a pyrophoric scrap incinerator. Although these release points are equipped with emission control devices, a small percentage of uranium can be released.

Liquid effluents originate from the use of water to quench hot uranium extrusions. RMI treats wastewater to remove uranium before it is discharged

to nearby waterways. To further treat plant liquid releases, RMI is proceeding with the design of an improved wastewater treatment system.

Oak Ridge National Laboratory

ORNL programs focus on the development of efficient, economical, safe, and environmentally acceptable technology for the production and use of energy from various sources. Relative to other DOE sites, these activities involve very little uranium. As a result, uranium releases to the air and water at ORNL have been and continue to be negligible and are not addressed in this report. As mentioned earlier, a small portion of the solid wastes containing enriched uranium generated at the Y-12 Plant are buried on the ORNL site.

URANIUM RELEASE DATA

Figures 1 through 6 illustrate historic trends in uranium released to the air and water for each of DOE/ORO's plants. Where possible, notes are provided on the graphs to explain significant increases and decreases in uranium releases. Note that for most facilities data are available only through 1983 since this report is drawn from source material prepared in late 1984. In addition, no graphs are included for ORNL because uranium releases at the ORNL site have been minor.

Generally, all the plants show a decreasing trend in uranium releases in recent years. Increased levels of uranium release indicate either an accidental release, an increase in production levels, or initiation of a different type of operation.

As the graphs show, all DOE/ORO plants began monitoring and recording uranium releases to the air and water by the mid-1950s, except for RMI, which did not become operational until 1962. Over the years, most plants have installed newer and more advanced pollutant control devices to decrease air releases. In addition, air and water monitoring and sampling programs have been and continue to be implemented in order to better characterize how and when uranium releases occur.

Table 1 shows total uranium releases to the air and water and uranium buried with solid wastes for each plant and for all DOE/ORO facilities combined. A quick glance at the numbers will show that, although large quantities (kilograms) of uranium have been released to the environment or buried on site, the level of radioactivity (curies) associated with the uranium released or buried is low. Most releases to the environment have been depleted uranium.

COMPARISON OF RISK WITH NATURAL SOURCES

The data presented in Table 1 and Figures 1 through 6 present releases of uranium by mass, measured in kilograms, or by radioactivity, measured in curies. A curie is the rate at which a radioactive material decays into other isotopes and, in the process, emits particles or energy (e.g., alpha or beta particles and gamma rays). Uranium has a relatively low number of curies per kilogram because the half-life of each of its isotopes is very long. Neither kilograms nor curies can be easily related to the degree of radiation dose or health effects experienced by an individual. The unit that is most often used to measure and discuss radiation dose to humans is a rem. Rems measure the amount of energy absorbed by a person who has been exposed to radiation.

Dose to individuals is usually discussed in terms of millirems--1/1000 of a rem--because the amounts of radiation are normally very small.

It should be noted that in Figures 1 through 6 different scales are used to illustrate the trends of uranium release. To put the information presented in these figures and in Table 1 into perspective, consider that the average U.S. resident receives about 200 millirems of radiation each year from natural and manmade sources. Sources of natural radiation include the sun, rocks, soil, food, air, and water. Because the sun is a major source of radiation, the elevation at which a person lives affects the level of radiation to which a person is exposed. Manmade sources include medical procedures such as x ray examinations, television, weapons fallout, and the nuclear fuel cycle.

When the average dose to a single individual is multiplied by the population within a specified area (within a 50-mile radius of a particular plant), the total amount of radiation received by the entire population is measured in person-rems.

Table 2 shows the cumulative person-rems of radiation dose within a 50-mile radius of each DOE/ORO facility. For example, over the 28 years for which uranium releases have been monitored at the Y-12 Plant, the dose to the total estimated population of 863,000 (1980 population) has been 5420 person-rems. By comparison, the same population over the same 28 years has received a dose of 4,000,000 person-rems of radiation from natural sources--cosmic rays from the sun, naturally radioactive elements contained in rocks and soil, building materials, air, water, and potassium in food. Thus, the additional radiation dose experienced due to operation of the Y-12 Plant, or any DOE/ORO facility, is minor when compared with natural sources of radiation.

Table 3 presents dose data in a different form. Based on available uranium release data, the table presents the effective total body dose, in millirems per year, to the member of the public having the highest calculated dose (the maximally exposed person) at each plant site. It also shows the maximum dose to a single organ of maximally exposed persons. Table 4 gives radiation doses from various natural and manmade sources with which to compare the dose from DOE/ORO facilities presented in Table 3. On January 17, 1985, the Environmental Protection Agency (EPA) published final standards for limiting airborne radionuclide releases from DOE facilities to an amount that results in a total body dose of 25 millirems per year or a maximum organ dose of 75 millirems per year. As shown in Table 3, the highest dose for any of the DOE/ORO facilities is well below the 1985 EPA standard.

COMPLIANCE WITH DOE REGULATIONS AND STANDARDS

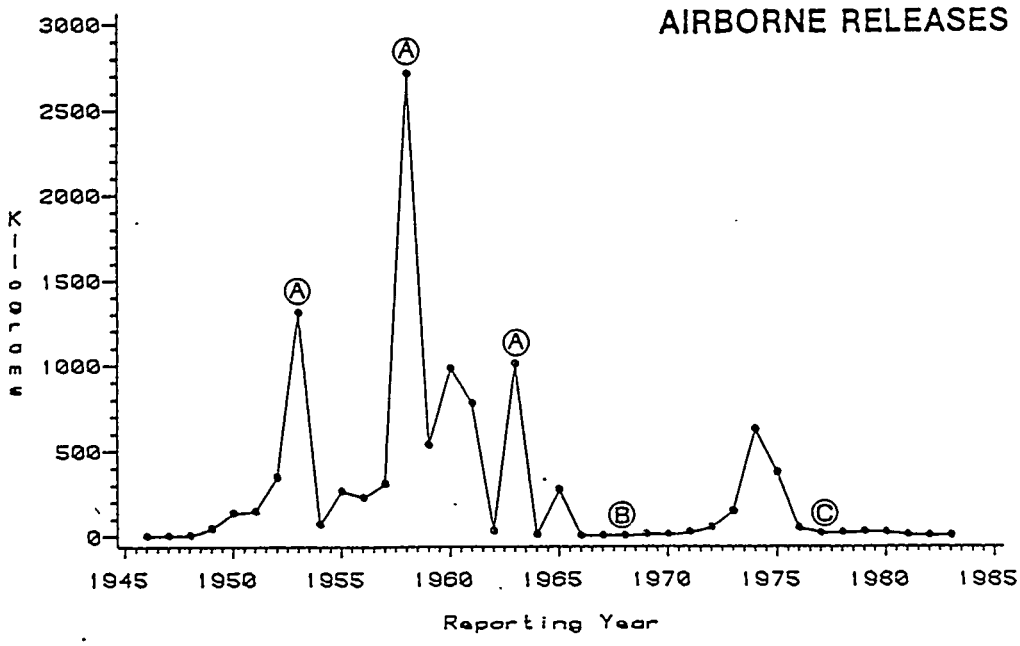
DOE standards are based on the assumption that any amount of radiation can cause an increased chance of harmful health effects. Thus, the levels of uranium released from DOE/ORO facilities have always been regulated--first under the Atomic Energy Commission (AEC), then under the Energy Research and Development Administration (ERDA), and finally under DOE. All annual releases at all DOE/ORO facilities have been in compliance with the DOE standards and regulations that were applicable at the time of release. In addition, work that RMI does for the private sector (i.e., non-DOE work) is regulated by the Nuclear Regulatory Commission (NRC). RMI's commercial operations have also been in compliance with NRC standards.

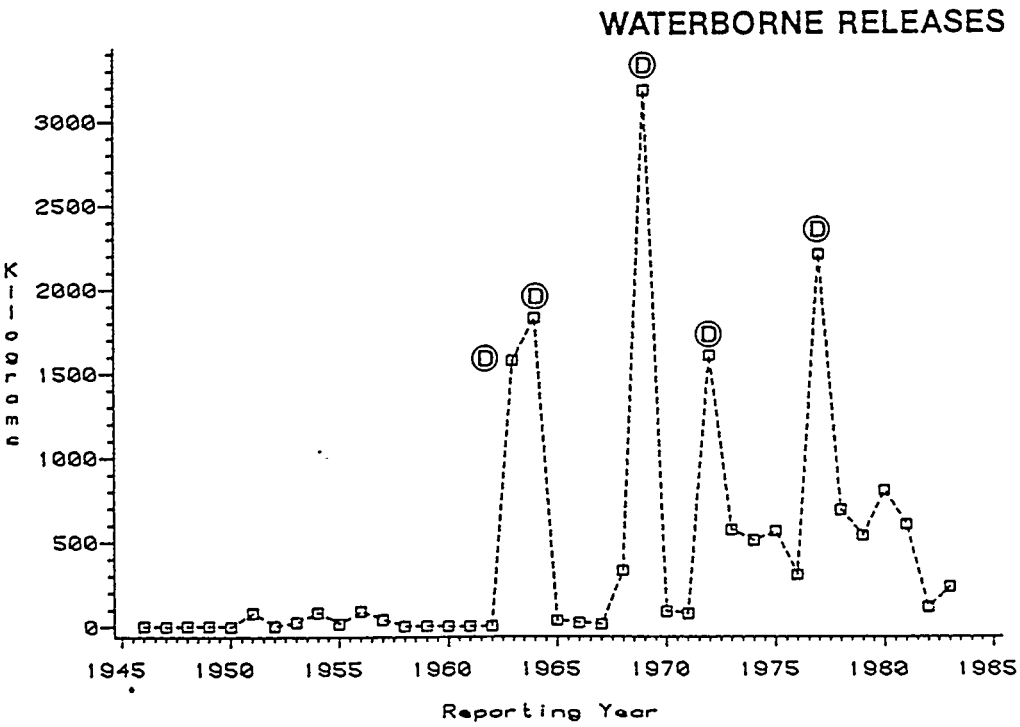
SUMMARY

In summary, the uranium release data for the DOE/ORO facilities show:

1. Large mass/small curie releases of uranium, primarily during the 1950s and 1960s.
2. Consistent compliance with DOE (AEC/ERDA) and NRC standards in effect at the time of release.
3. Dose to maximally exposed person well within EPA dose standards (see Table 3).
4. A decreasing trend in uranium release to air and water at most facilities as a result of improved effluent controls.

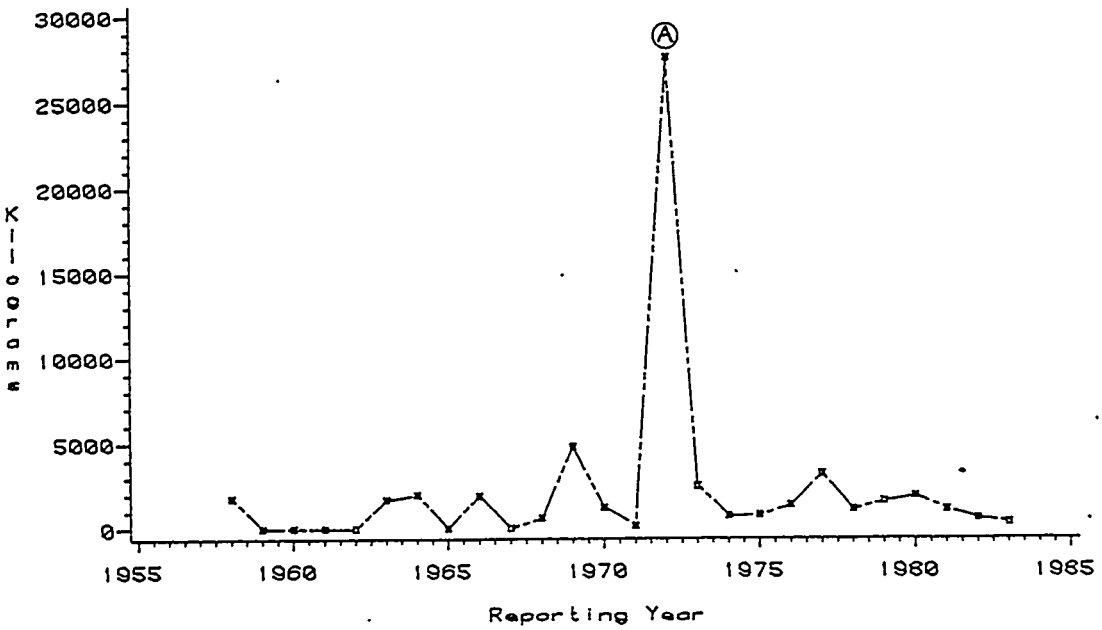
FIGURE 1A. ANNUAL RELEASES OF URANIUM TO THE AIR AND WATER FROM OAK RIDGE GASEOUS DIFFUSION PLANT





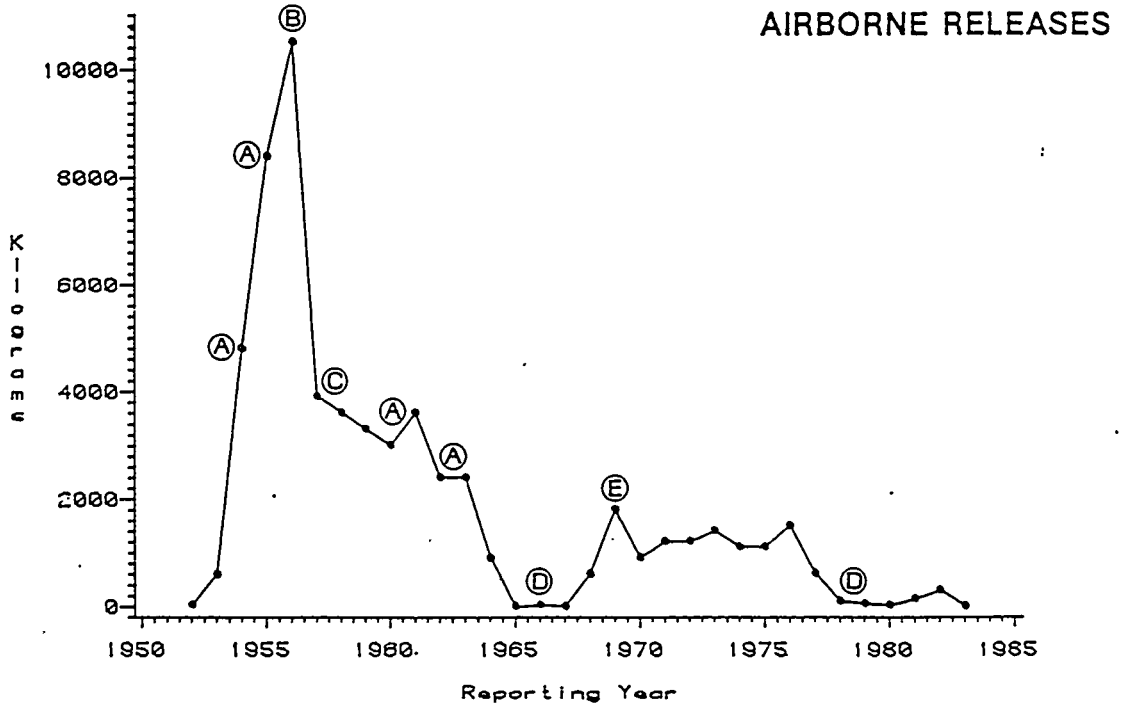
Ⓐ — Accidental Release
Ⓑ — Declining Production Levels
Ⓒ — Improved Control Technology
Ⓓ — Periodic Equipment Decontamination

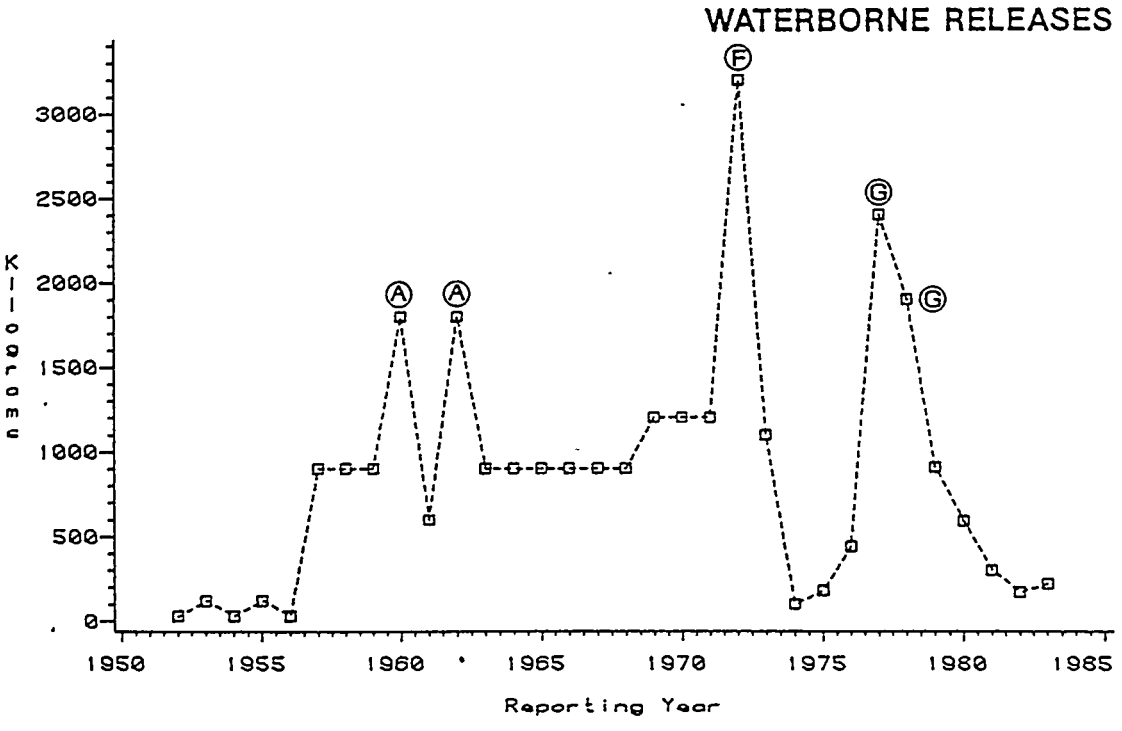
FIGURE 1B. URANIUM BURIED ANNUALLY ON SITE AT OAK RIDGE GASEOUS DIFFUSION PLANT



Ⓐ — Burial of Contaminated Scrap From Previous Years

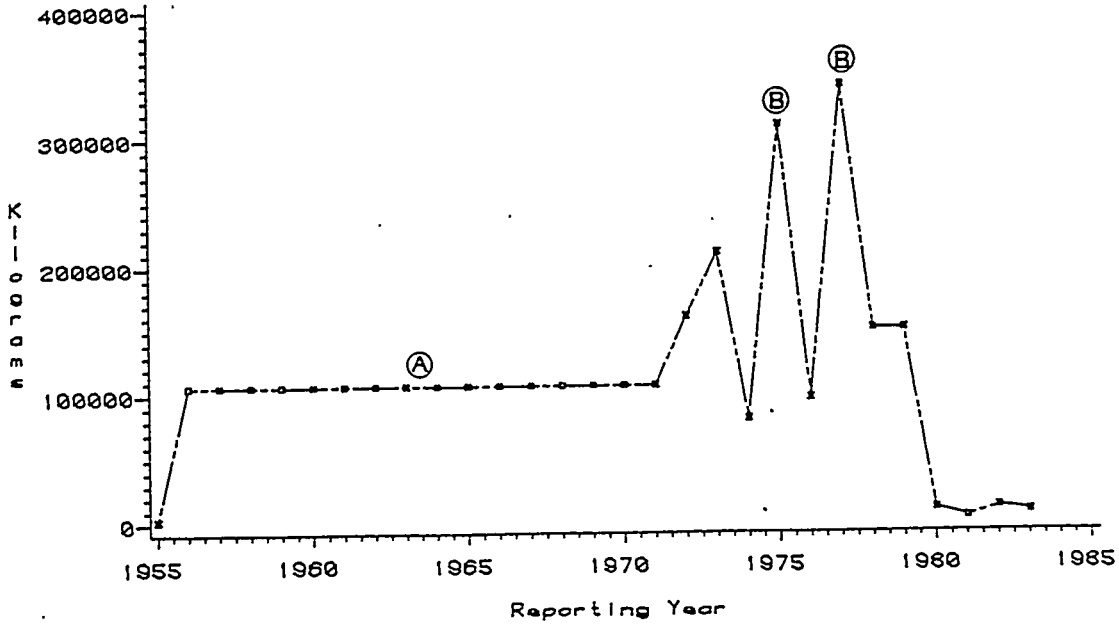
FIGURE 2A. ANNUAL RELEASES OF URANIUM TO THE AIR AND WATER FROM PADUCAH GASEOUS DIFFUSION PLANT





Ⓐ – Accidental Release
Ⓑ – Increased Production
Ⓒ – Improved Control Technology
Ⓓ – Unit Operations Shutdowns
Ⓔ – Unit Operations Reactivation
Ⓕ – Operational Release
Ⓖ – Equipment Decontamination

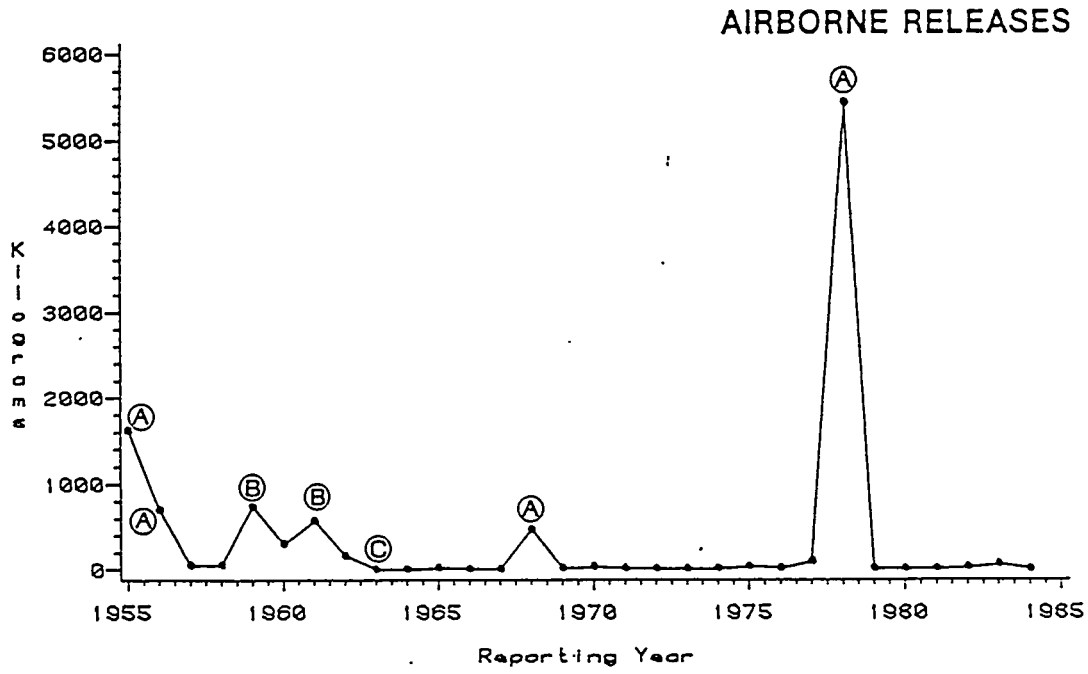
FIGURE 2B. URANIUM BURIED ANNUALLY ON SITE AT PADUCAH GASEOUS DIFFUSION PLANT

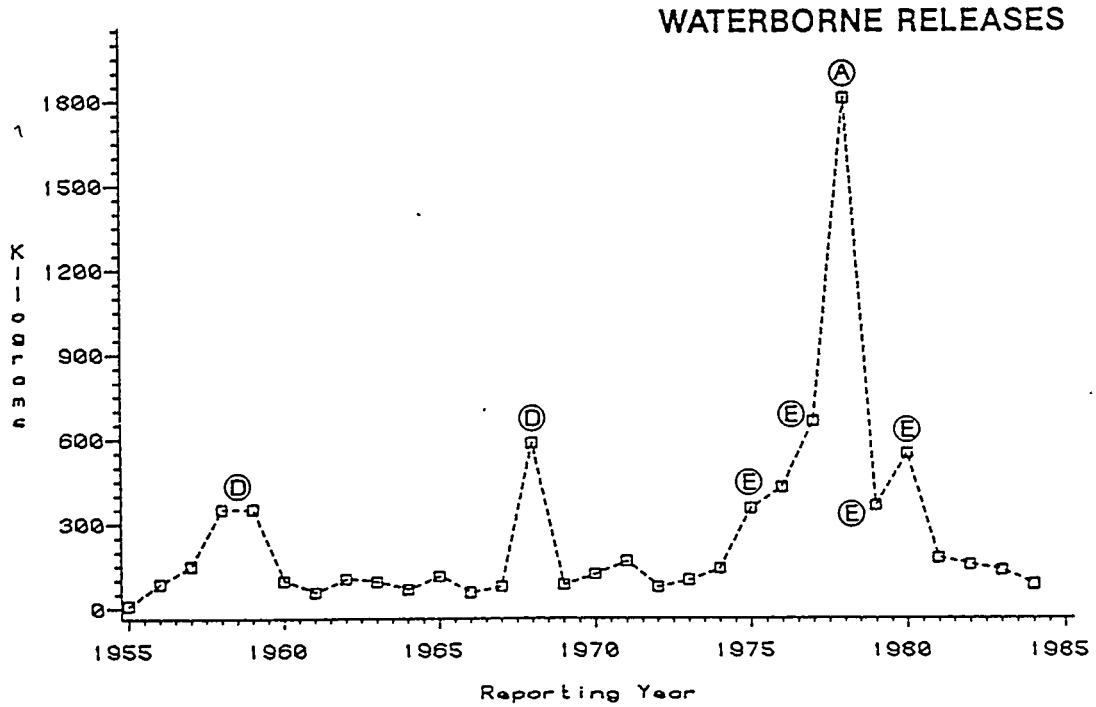


Ⓐ – Annual Data Unavailable for 1955–1971 Graph Shows Total 1,700,000 Kilograms Averaged Over Time Period

Ⓑ – Increased Production

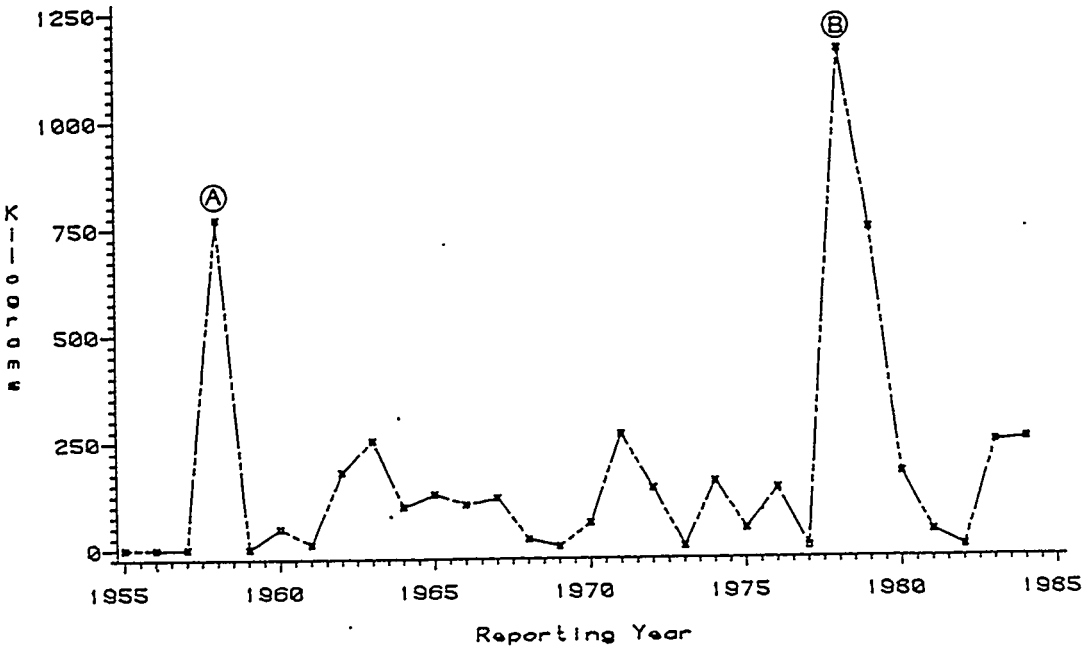
FIGURE 3A. ANNUAL RELEASES OF URANIUM TO THE AIR AND WATER FROM PORTSMOUTH GASEOUS DIFFUSION PLANT





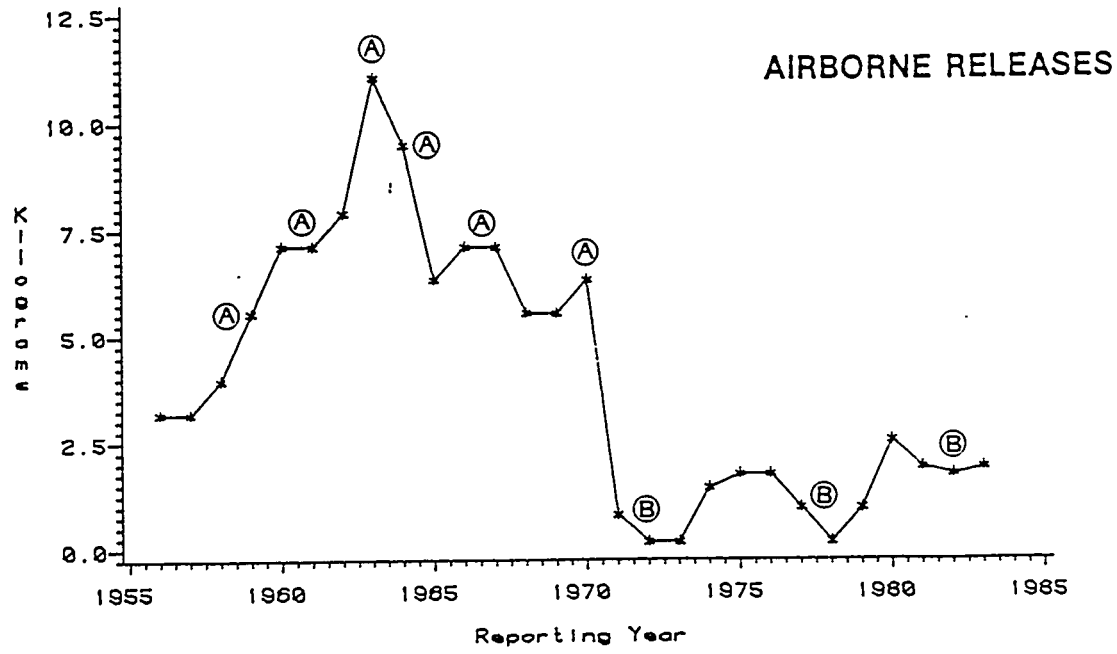
Ⓐ — Accidental Release
Ⓑ — Operation of Feed Production Plant
Ⓒ — Shutdown of Feed Production Plant
Ⓓ — No Documentation Available
Ⓔ — Increased Equipment Decontaminati

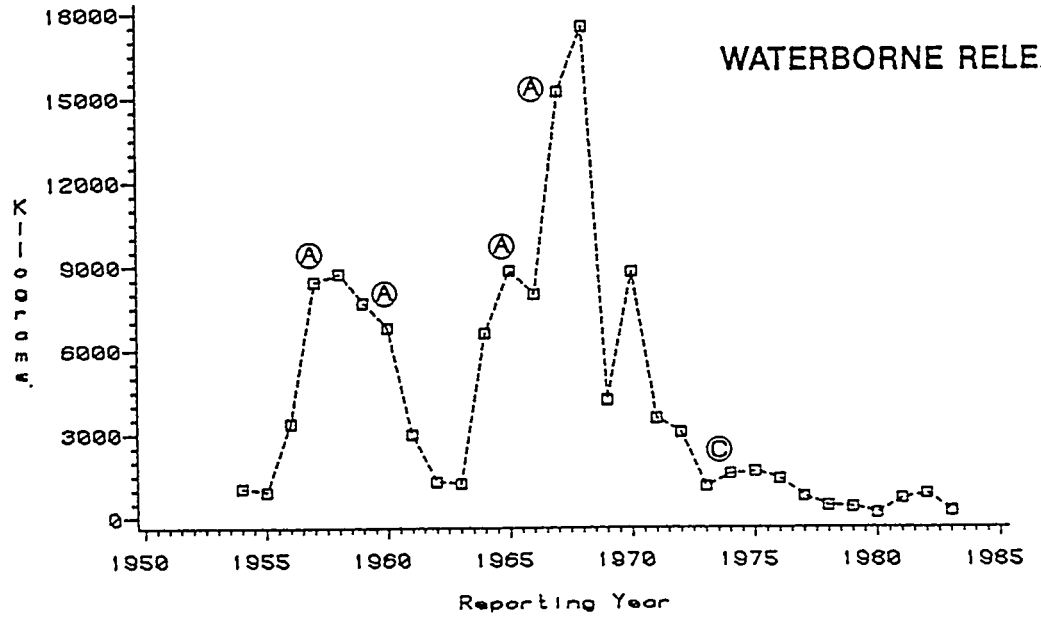
FIGURE 3B. URANIUM BURIED ANNUALLY ON SITE AT PORTSMOUTH GASEOUS DIFFUSION PLANT



Ⓐ — No Documentation Available
Ⓑ — Scrap Resulting from Increased Production

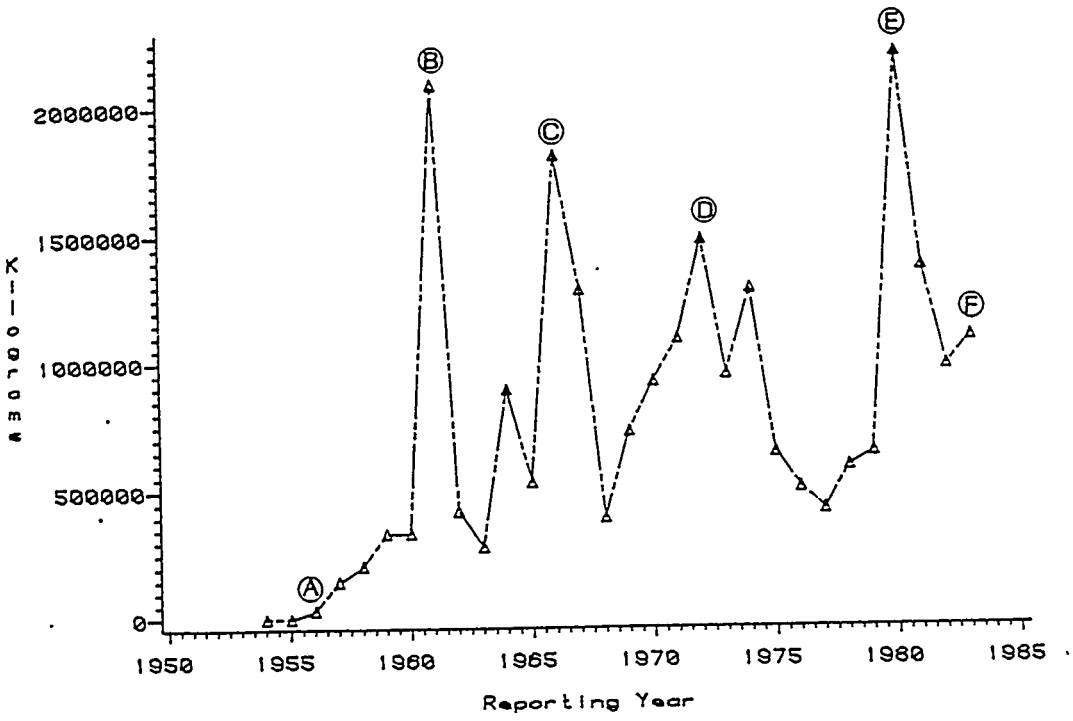
FIGURE 4A. ANNUAL RELEASES OF URANIUM TO THE AIR AND WATER FROM THE Y-12 PLANT





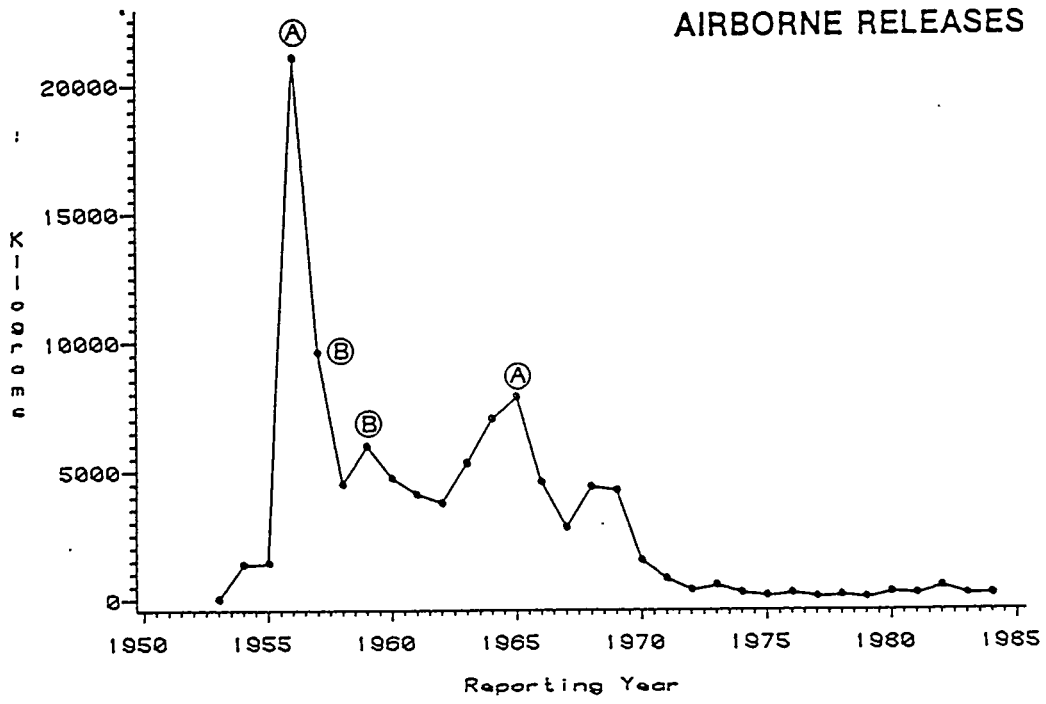
Ⓐ — Increased Production
Ⓑ — Improved Control Technology
Ⓒ — New Recovery/Recycle Process

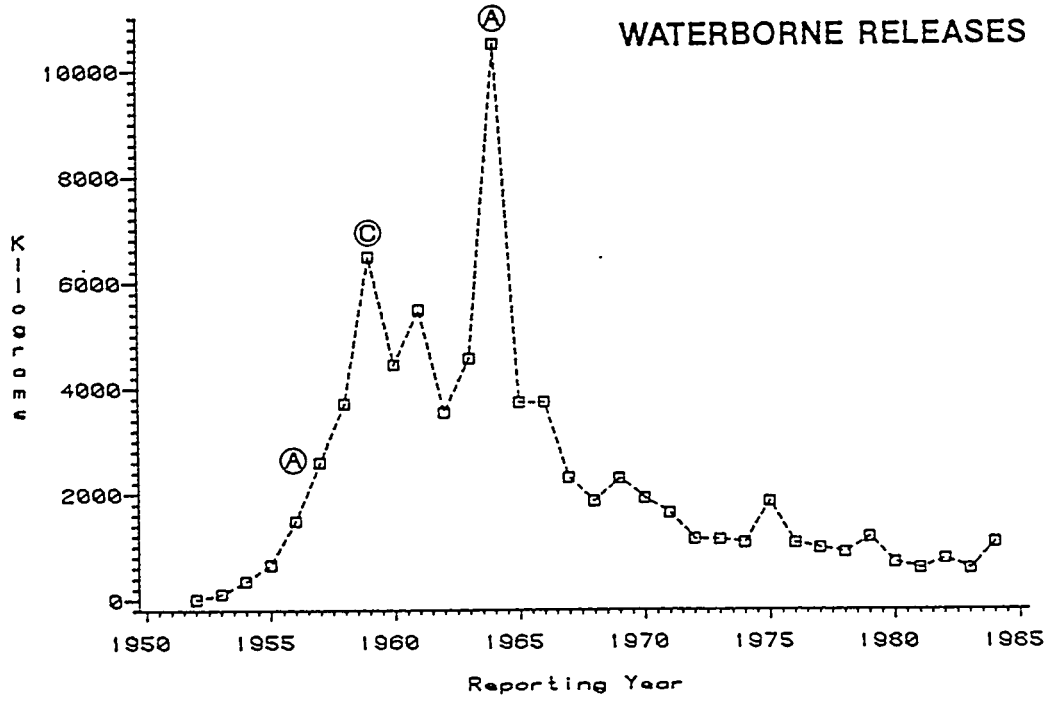
FIGURE 4B. URANIUM BURIED ANNUALLY ON SITE AT THE Y-12 PLANT



Ⓐ – Majority of Uranium Disposed Off Site
Ⓑ – Increased On Site Burial (Off Site Burial Discontinued)
Ⓒ – No Documentation Available
Ⓓ – Increased Production
Ⓔ – Changes in Reporting Program
Ⓕ – Most Burial Expected to Cease During 1985

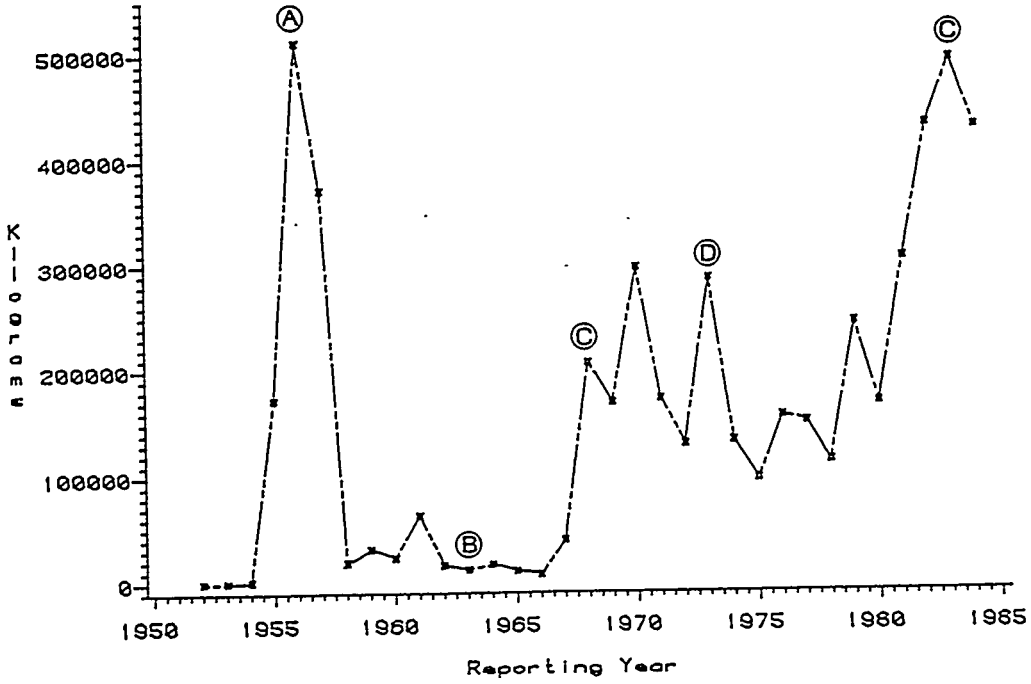
FIGURE 5A. ANNUAL RELEASE OF URANIUM TO THE AIR AND WATER FROM THE FEED MATERIALS PRODUCTION CENTER





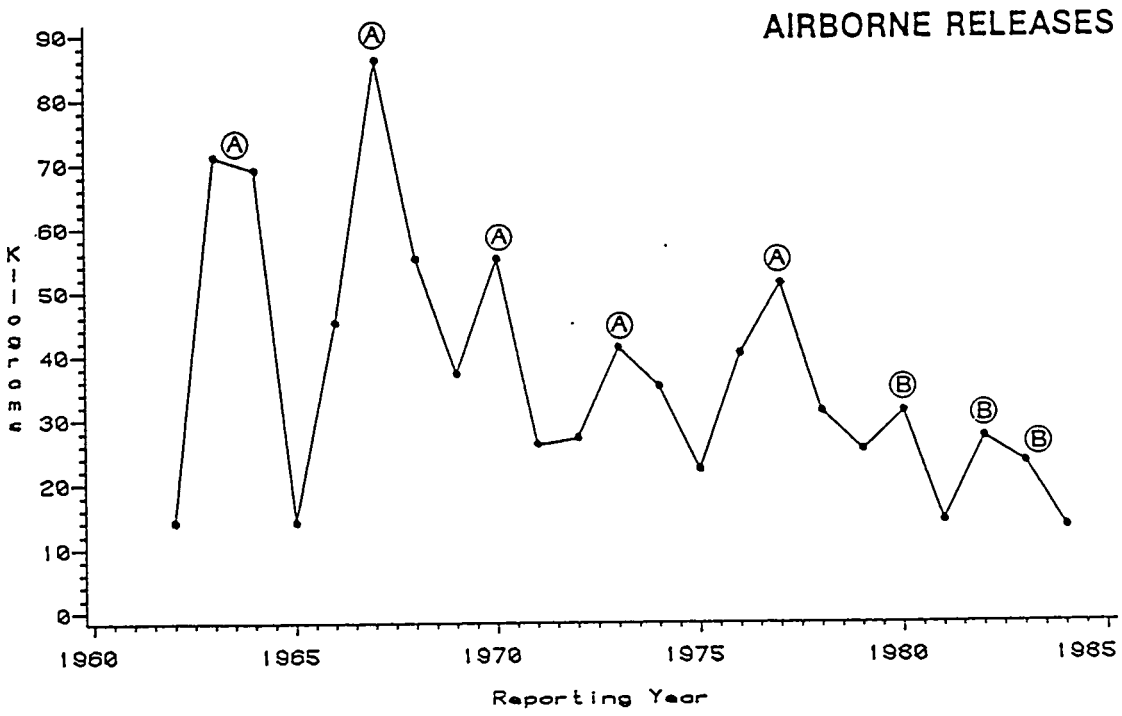
Ⓐ — Increased Production
Ⓑ — Improved Control Technology
Ⓒ — Accidental Release

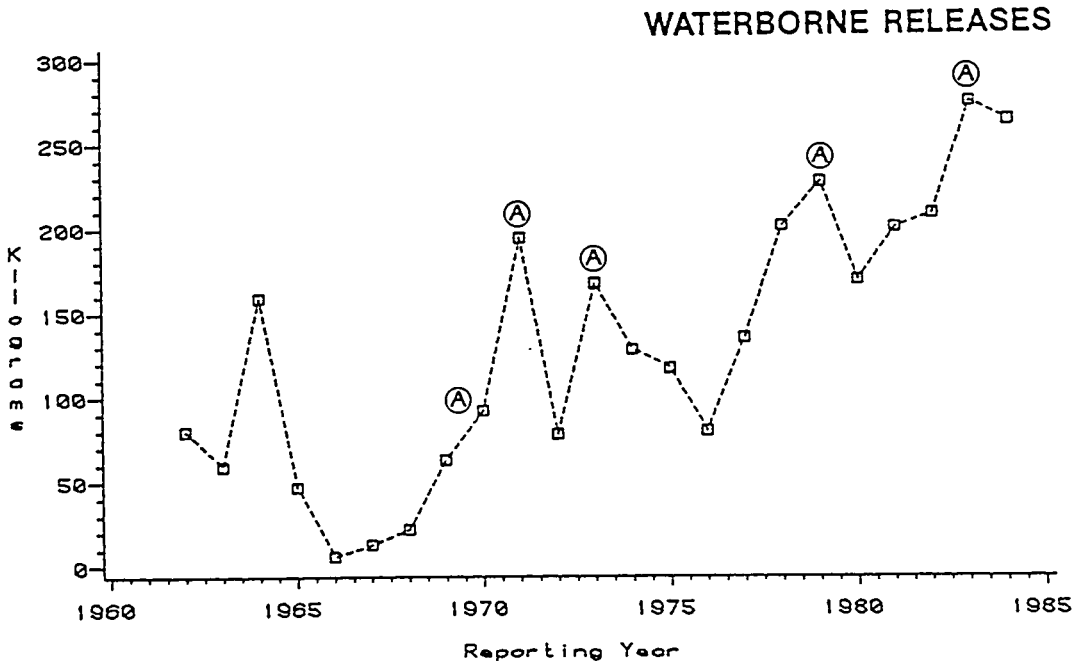
FIGURE 5B. URANIUM BURIED ANNUALLY ON SITE AT THE FEED MATERIALS PRODUCTION CENTER



Ⓐ – No Documentation Available
Ⓑ – Decreased Production
Ⓒ – Increased Production
Ⓓ – Unit Operations Reactivation

FIGURE 6A. ANNUAL RELEASES OF URANIUM TO THE AIR AND WATER FROM THE RMI EXTRUSION PLANT





Ⓐ — Increased Production
Ⓑ — Improved Control Technology

TABLE 1

TOTAL URANIUM RELEASED TO AIR AND WATER AND BURIED AT DOE/ORO FACILITIES SINCE REPORTING WAS INITIATED

		ORGDP	Paducah GDP	Portsmouth GDP	Y-12	FMPC	RMI	ORNL[a]	7-Plant Tota
Reporting Period	from:	1946-	1952-	1955-	1956-	1952-	1962-	1956-	
	to:	1983	1983	1984	1983	1984	1984	1983	
Air									
Curies		15.60	33.27	7.9	8.3	31.98	0.57		
Kilograms		10,515	59,522	10,437	3,200	97,681	851	--	182,206
Water									
Curies		14.34	14.95	13.16	85.21	24.77	2		
Kilograms		16,227	27,740	7,531	127,000	~~170,262~~ 74,308	2,982	--	~~351,742~~ 255,78
Ground (burial)[b]									
Curies		33.70	1,327	3.4	8,468	1,750.5	0		
Kilograms		56,500	3,230,000	5,120	23,000,000	5,252,012	0	435,000	31,978,632

[a]Air and water releases of uranium from ORNL have been very small. The uranium buried on the ORNL site is uran bearing solid wastes from Y-12 operations.

[b]The large quantities of uranium-bearing solid wastes buried at DOE/ORO facilities are contained on site in a restri access area.

31,978,632
2.2046 lb

70,500,092 lb

TABLE 2

COMPARISON OF TOTAL POPULATION DOSE RESULTING FROM OPERATION OF DOE/ORO FACILITIES VS. NATURAL BACKGROUND RADIATION

	ORGDP	Paducah GDP	Portsmouth GDP	Y-12	FMPC[a]	RMI	ORNL[b]
Reporting Period from: to:	1946-1983[c] (37 yrs)	1952-1983[c] (31 yrs)	1955-1984 (29 yrs)	1956-1983[c] (27 yrs)		1962-1984 (22 yrs)	
Population within 50-mile radius (1980)	837,000	454,000	600,000	863,000	--	1,600,000	--
Dose to total population within 50-mile radius, accumulated over reporting period, person-rems[d]	850	760	453	5,420	--	340	--
Natural background within 50-mile radius, accumulated over reporting period, person-rems	4,900,000	2,500,000	120,000/yr[e]	4,000,000	--	200,000/yr[e]	--

[a] Data are still being collected to allow comparable calculations for FMPC.

[b] No comparable calculations have been performed because the uranium releases at ORNL have been so small.

[c] 1984 data for ORGDP, Paducah, and Portsmouth will be available in the annual Environmental Monitoring Reports.

[d] Airborne release pathway only; waterborne pathway is a minor additional contributor to public radiation exposure.

[e] Yearly background values; not accumulated values.

TABLE 3

CURRENT[a] DOSES TO MAXIMALLY EXPOSED PERSONS FROM URANIUM RELEASES AT DOE/ORO FACILITIES

	ORGDP (1983)	Paducah GDP (1983)	Portsmouth GDP (1984)	Y-12 (1983)	FMPC[b]	RMI (1984)	ORNL[c]	Natural Background (U.S. Average)	1985 EPA Standar 70-25
Effective Total Body Dose, millirems/year[e]	<1	<1	<1	4.4	--	3.8	--	200	25
Maximum Organ Dose, millirems/year[e]	<1	<1	<1	15	--	13	--	--	75

[a]Doses are calculated from 1983 data for ORGDP, Paducah, and Y-12 and from 1984 data for Portsmouth and RMI.

[b]Data are still being collected to allow comparable calculations for FMPC.

[c]No comparable calculations have been performed because the uranium releases at ORNL have been minor.

[d]EPA standard is for uranium plus all other radionuclides released from facility.

[e]Airborne release pathway only; waterborne pathway is a minor additional contributor to public radiation exposure.

TABLE 4

NATURAL AND MANMADE SOURCES OF RADIATION

Natural	Dose (millirems/year)[a]	Manmade	Dose (millirems)
Cosmic radiation			
Connecticut	40	Gas stove	15 per year[a]
Wyoming	130	Gas camping lantern (silk mantle)	3 per hour[a]
Colorado	120		
Soil and rocks			
Connecticut	60		
South Dakota	115	Jet plane travel	1 per 2500 miles traveled[b]
Colorado	105		
Food (potassium), water, air	24	TV viewing	0.15 per hour[b]
Type of House			
Brick	50-100		
Concrete	70-100		
Wood	30-50		

[a]Data from Northeast Utilities brochure, as supplied by National Academy of Sciences, U.S. Environmental Protection Agency, and American Nuclear Society.

[b]Data from "Personal Radiation Dose Chart," American Nuclear Society, 1980.

DOE-ORGDP
Airborne Uranium Emissions
1946 - 1983

YEAR	Total Uranium Radioactivity Released (Ci/yr)	Total Mass of Uranium Released (kg/yr)
1946	0.01	1
1947	<0.01	<1
1948	<0.01	5
1949	<0.01	45
1950	0.10	136
1951	0.02	146
1952	0.23	345
1953	1.60	1,307*
1954	0.26	68
1955	0.26	264
1956	0.81	225
1957	0.15	306
1958	1.80	2,711*
1959	1.10	531
1960	1.50	977
1961	3.10	773
1962	0.24	29
1963	3.10	1,005*
1964	0.01	7
1965	0.14	269
1966	<0.01	1**
1967	<0.01	2
1968	<0.01	<1
1969	<0.01	9
1970	<0.01	8
1971	0.02	21
1972	0.03	49
1973	0.13	144
1974	0.44	622
1975	0.27	371
1976	0.05	45
1977	0.03	17
1978	0.02	19
1979	0.04	25
1980	0.03	21
1981	0.01	5
1982	<0.01	2
1983	<0.01	2
TOTAL	15.60[1]	10,515[1]

[1]This total includes the actual stated value for any quantity which was reported as a less than (<) value.

Note: The isotopic content of the uranium released varies strongly from year to year (Uranium-235 content varies from 0.2 percent to 90+ percent). The variability of isotopic content and quantities released results in much year to year variation.

* A major portion of the quantities reported in 1953, 1958, and 1963 resulted from accidental releases due to valve and trap failures in the K-402-1, K-1131, and K-1420 feed and processing facilities.

** Declining production levels was a factor which reduced emissions in the 1966-70 time period.

DOE-ORGDP
Liquid Effluent Uranium Releases
1946 - 1983

YEAR	Total Uranium Radioactivity Released (Ci/yr)	Total Mass of Uranium Released (kg/yr)
1946	<0.01	<1
1947	—	—
1948	0.03	4
1949	<0.01	3
1950	—	—
1951	0.05	80
1952	<0.01	4
1953	0.10	26
1954	0.23	84
1955	0.05	16
1956	0.24	90
1957	0.18	40
1958	<0.01	<1
1959	<0.01	5
1960	<0.01	<1
1961	0.02	2
1962	0.01	2
1963	5.10**	1,576*
1964	1.10	1,826*
1965	0.01	33
1966	<0.01	21
1967	<0.01	12
1968	0.26	330
1969	0.04	3,180*
1970	0.86	88
1971	0.44	76
1972	0.40	1,601
1973	0.44	570
1974	0.4	508
1975	1.70	564
1976	0.54	306
1977	0.42	2,201*
1978	0.63	688
1979	0.47	537
1980	0.09	803
1981	0.18	601
1982	0.09	114
1983	0.18	233
TOTAL	14.34[1]	16,227[1]

— Indicates data not available

[1]This total includes the actual stated value for any quantity which was reported as a less than (<) value.

Note: The isotopic content of the uranium released varies from year to year (Uranium-235 content varies from 0.2 percent to 90+ percent). The variability of isotopic content and quantities released results in much year to year variations.

* A major portion of the quantities reported in 1963, 1964, 1969, 1972, and 1977 resulted from discharges to a pond from the decontamination facility.

** Enriched material.

DOE-ORGDP
Uranium Contained in Solid Waste Buried on Site

YEAR	Total Uranium Radioactivity Buried (Ci/yr)	Total Mass of Uranium Buried (10^3 kg/yr)
1958	1.20	1.79
1963	5.50	1.70
1964	1.10	1.99
1965	<0.01	<0.01
1966	0.99	1.93
1968	0.37	0.60
1969	1.80	4.78
1970	0.87	1.21
1971	0.08	0.13
1972	10.70	27.50*
1973	1.80	2.46
1974	0.55	0.71
1975	0.59	0.76
1976	0.95	1.34
1977	2.50	3.18
1978	0.85	1.09
1979	1.20	1.56
1980	1.20	1.86
1981	0.83	1.06
1982	0.43	0.55
1983	0.18	0.29
TOTAL	33.70	56,500 kgs

ote: The ratio between curies and mass differs from year to year due to varying isotopic enrichments.

* Contaminated scrap from previous years was buried.

Surface Water Concentration
10^{-14} Ci/mL

Year	*No. 1	*No. 2	*No. 3	*No. 4	*No. 5	*No. 6	Concentrat Guide
1959	6.2		0.6				2,000
1960	3.1		0.7	0.14	0.27		2,000
1961				0.16	0.25		2,000
1962				0.06	0.2		2,000
1963							2,000
1964				0.1	0.1		2,000
1965				<0.1	<0.1		2,000
1966					<0.1		2,000
1967					<0.1		2,000
1968					<0.2		2,000
1969					<0.1		2,000
1970					<0.1		2,000
1971		2.5	7.1		0.3		2,000
1972		1.0	0.4		0.2		2,000
1973		0.6	0.1	<0.2	0.2		3,000
1974		3.2	2.1	0.5	0.3		3,000
1975		1.6	1.0	0.3	0.4		3,000
1976		1.2	1.4	0.5	<0.6	<0.5	3,000
1977		1.0	0.6	0.3	0.2	0.3	3,000
1978		<0.3	<0.4	<0.1	<0.3	<0.3	3,000
1979		<0.4	0.5	<0.2	<0.3	<0.2	3,000
1980		<0.2	<0.4	<0.09	<0.2	<0.1	**
1981		0.5	0.6	<0.01	<0.1	<0.2	**
1982		<0.2	<0.3	<0.1	<0.1	<0.1	**
1983		<0.4	<0.4	<0.2	<0.2	<0.2	**

*1. Mouth of East Fork Poplar Creek

*2. Above K-25 Poplar Creek

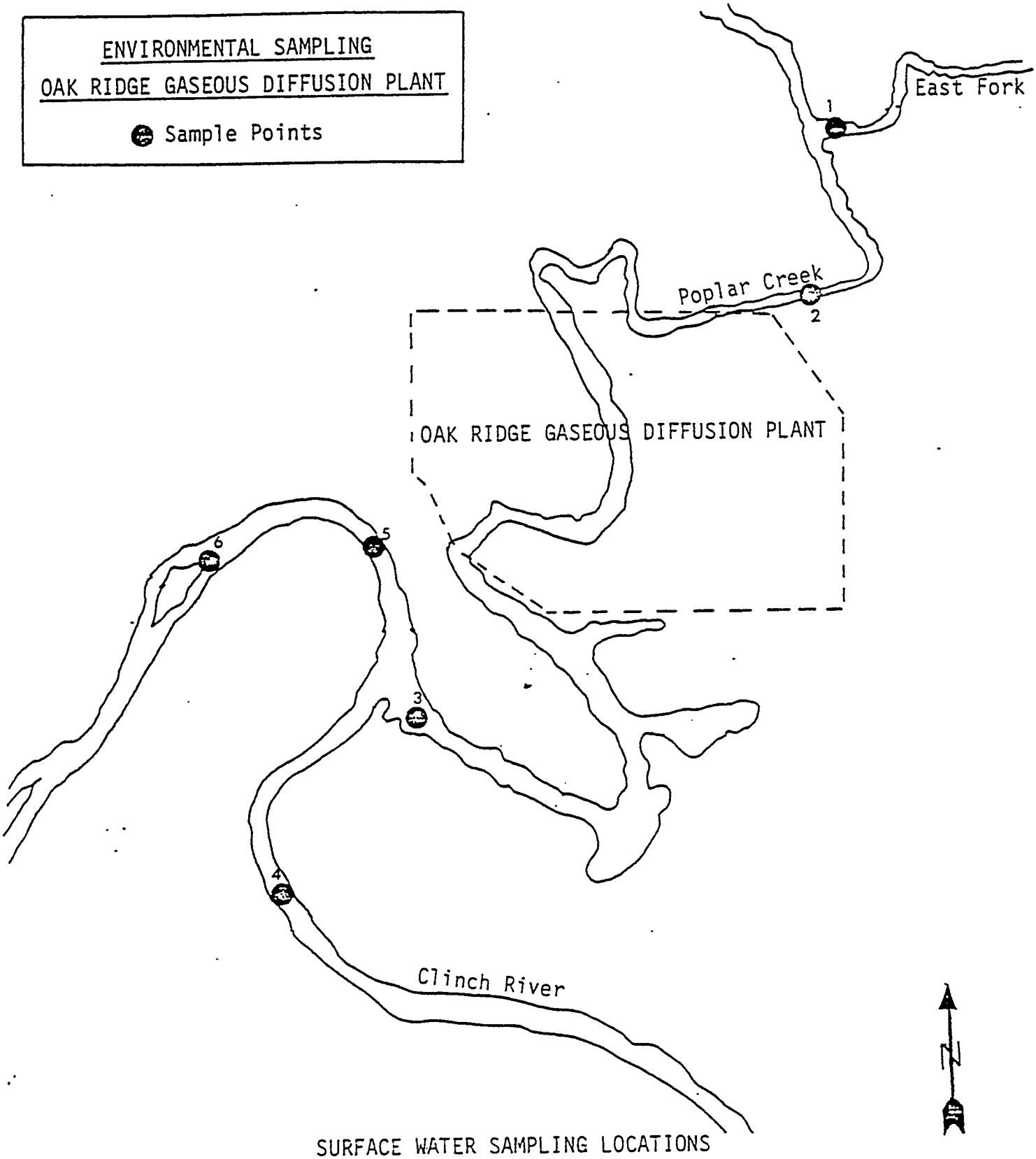
*3. Mouth of Poplar Creek

*4. Above K-25 Clinch River

*5. Below K-25 Clinch River

*6. Brashear Island Clinch River

** - Beginning in 1980, a dose standard as opposed to the concentration standard was adopted.



SURFACE WATER SAMPLING LOCATIONS

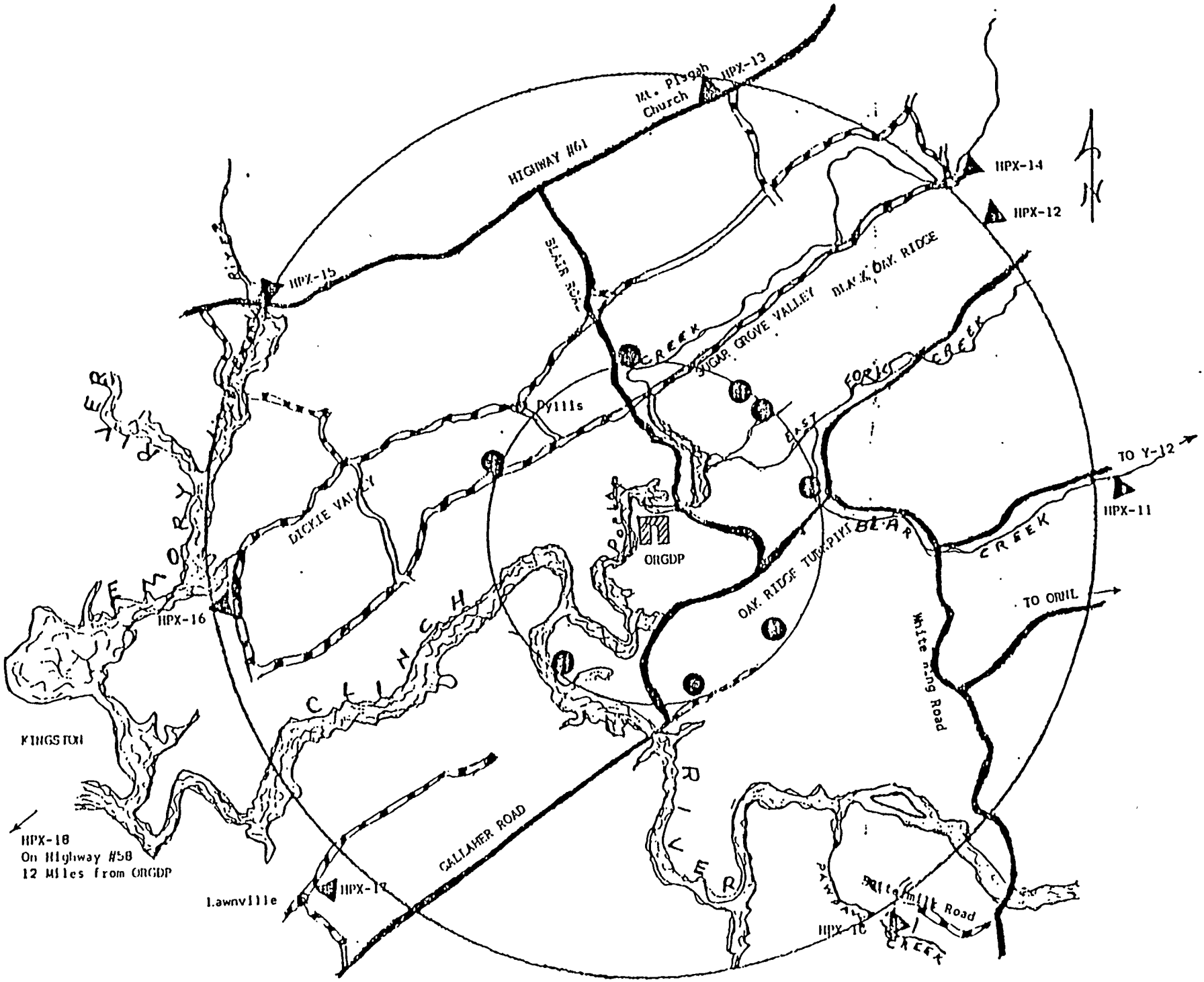
ORGDP Annual Air Concentration
(1960 - 1965)
10^{-13} µCi/mL

Year	Distance From ORGDP	Average*** Concentration	Concentration Guide
1960*	2 miles	1.1	20
1960*	5 miles	3.1	20
1961	2 miles	0.4	20
1961**	5 miles	1.0	20
1962	5 miles	1.6	20
1963	5 miles	4.0	20
1964	5 miles	2.5	20
1965	5 miles	0.8	20

* Not included in this data are thirty-two samples taken in early November which coincided with an onsite pilot plant operation. These values showed 188 x 10^{-13} µCi/mL at two miles and 110 x 10^{-13} µCi/mL at five miles.

** After 1961 the two mile stations were not maintained.

*** The values in Table 4 are higher than the values in Table 5 because the data in Table 4 were collected without waiting for the background daughter products to decay. The air monitors used during this period automatically counted the air samples only 4.5 hours after collection. Sampling methods were changed in 1966 to correct this deficiency.



SAMPLING POINTS OF OUTSIDE ENVIRONS -- ORGDP

Air

▲ Sampling Location - 5 Miles from Plant

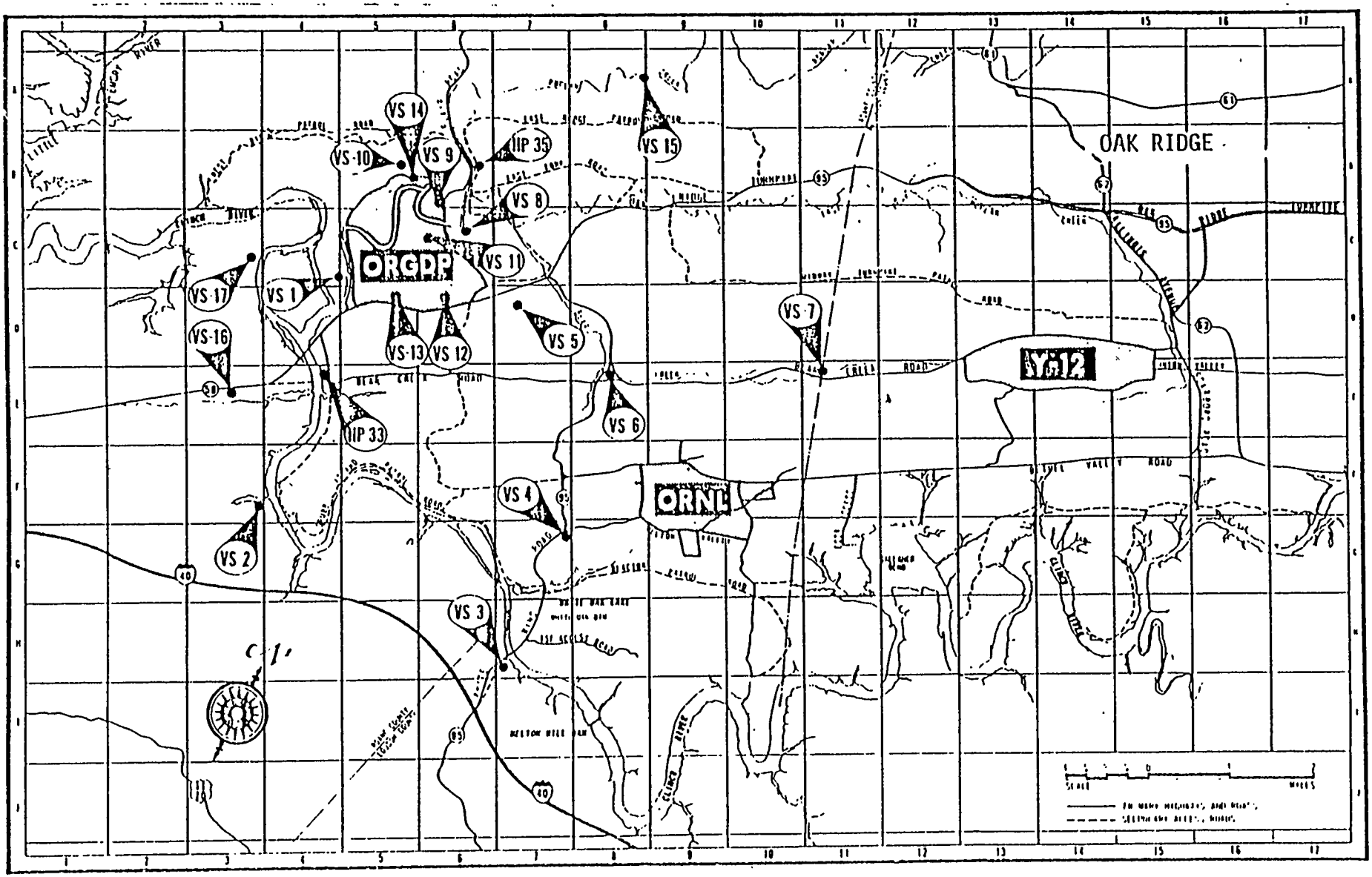
Annual Air Concentration (1966-1983)
(Average Gross Alpha Activity - 10^{-15} μCi/mL)

Year	Location HP - 33 Gallaher Gate	*Percentage of Concentration Guide (%)	Location HP-35 Blair Gate	*Percentage o Concentratio Guide (%)
1966	5.0	.12	7.0	.17
1967	3.0	.07	5.0	.12
1968	1.5	.04	2.0	.05
1969	1.5	.04	2.0	.05
1970	1.0	.02	1.0	.02
1971	1.0	.02	1.0	.02
1972	2.0	.05	3.0	.07
1973	1.6	.04	2.3	.06
1974	1.5	.04	1.6	.04
1975	1.4	.03	1.6	.04
1976	1.7	.04	3.1	.08
1977	1.6	.04	1.3	.03
1978	1.1	.03	2.2	.05
1979	1.2	.03	1.5	.04
1980	1.1	**	1.5	**
1981	0.8	**	0.9	**
1982	1.1	**	1.0	**
1983	1.3	**	1.0	**

* The applicable concentration guide until 1980 was 4.0×10^{-12} μCi/mL.

** Beginning in 1980, a dose standard as opposed to the concentration standard was adopted.

DWG. NO. K/G-85-4261
(U)



AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

Uranium in Soil

(µg/g)

	1975	1976	1977	1978	1979	1980	1981	1982*	1983
VS-1	2.1	1.5	4.1	3.0	2.4	2.1	2.3	1.5	4.2
VS-2	4.8	1.5	1.0	1.7	1.6	3.0	3.4		
VS-3	1.1	1.1	2.0	3.1	2.6	2.2	3.2		
VS-4	0.4	0.8	1.1	1.8	3.1	1.9	3.3		
VS-5	1.1	0.6	2.4	2.7	2.2	2.5	2.2	2.9	4.7
VS-6	0.9	1.1	2.1	4.2	4.6	1.8	3.9		
VS-7	0.5	0.8	2.2	2.2	2.0	5.4	2.6		
VS-8	1.1	1.7	4.2	5.8	4.1	5.5	4.1	4.9	4.6
VS-9	0.8	0.4	1.6	2.7	2.6	4.5	2.4	1.8	2.4
VS-10	0.6	0.3	3.4	3.9	2.3	2.2	1.8	2.0	2.3
VS-11	1.4	0.9	2.9	4.5	4.9	2.5	5.3	4.6	6.0
VS-12	1.0	0.6	1.8	2.1	3.4	2.0	2.9		
VS-13	2.9	2.8	4.2	4.9	3.7	2.9	2.8	2.5	3.7
VS-14	1.2	1.9	2.1	2.4	3.2	1.5	2.3		
VS-15	1.5	1.0	3.7	3.5	4.0	3.2	5.4	3.2	3.8
VS-16	1.0	2.4	1.9	2.0	4.1	2.2	2.5	1.6	2.8
VS-17	2.9	1.0	5.8	6.5	3.3	3.2	1.6	2.2	1.6
Annual Average	1.5	1.2	2.7	3.3	3.2	2.8	3.1	2.7	3.6

* In 1982, the number of soil sampling locations was reduced.

Uranium in Pine Needles

(µg/g)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
VS-1	<0.1									
VS-2	<0.1	<0.1	<0.1	0.89	0.04	0.06	0.2	0.09		
VS-3	<0.1	<0.1	0.1	0.26	0.06	0.05	0.3	0.1		
VS-4	<0.1	<0.1	0.1	0.07	0.2	0.1	0.2	0.3		
VS-5	<0.1	0.2	0.4	0.21	0.2	0.2	0.5	0.1	0.1	0.32
VS-6	<0.1	<0.1	0.1	0.08	0.04	0.09	0.3	0.2		
VS-7	0.3	<0.1	0.1	0.11	0.09	0.1	0.2	0.1		
VS-8	0.6	0.3	0.2	0.47	0.2	0.3	0.4	0.6	0.2	0.24
VS-9	<0.1	0.3	0.2	1.00	0.2	0.09	0.2	0.1	0.05	0.10
VS-10	<0.1	2.4	0.1	0.45	0.1	0.1	0.1	0.9	0.4	0.16
VS-11			0.3	0.82	0.5	0.5	1.1	0.4	0.1	0.20
VS-12			0.2	0.24	0.2	0.2	0.4	0.3		
VS-13*										
VS-14			<0.1							
VS-15			<0.1	0.25						
VS-16			0.2	0.18				0.1	0.08	0.13
VS-17			0.1	0.19				0.07	0.09	0.05
Annual Average	<0.2	<0.4	<0.2	0.4	0.2	0.2	0.3	0.3	0.1	0.2

* No pine needles available at this site.

** The number of sampling locations were reduced.

Uranium in Grass
(µg/g)

	1974	1975	1976	1977	1978	1979	1980	1981	1982*	1983
VS-1	0.1	0.3	0.5	0.20	0.2	0.1	0.6	0.3	0.2	0.21
VS-2	0.6	0.1	0.1	0.08	0.05	0.1	1.6	0.2		
VS-3	0.1	0.1	0.1	0.04	0.04	0.1	1.2	0.06		
VS-4	0.2	0.3	0.7	0.38	0.2	0.1	0.7	0.1		
VS-5	<0.1	0.1	0.2	0.07	0.3	0.1	0.7	0.4	0.3	0.20
VS-6	<0.1	0.3	0.2	0.07	0.6	0.08	0.6	0.2		
VS-7	<0.1	0.2	0.1	0.06	0.5	0.1	0.5	0.5		
VS-8	<0.1	0.4	0.3	0.29	1.0	0.2	0.6	0.2	0.2	0.08
VS-9	<0.1	0.3	0.1	1.22	0.4	0.2	0.7	0.2	0.1	0.06
VS-10	<0.1	<0.1	0.1	0.16	0.4	0.1	0.5	0.2	0.2	0.05
VS-11			0.4	0.53	1.2	0.7	1.7	0.5	0.4	0.08
VS-12			0.2	0.12	0.4	0.2	0.4	0.2		
VS-13			0.1	0.51	0.8	0.1	1.1	0.6	0.6	0.63
VS-14			0.3	0.27	0.3	0.04	0.5	0.02	<0.1	
VS-15			0.1	0.07	0.3	0.04	0.6	0.2	0.2	0.08
VS-16			0.1	0.04	0.5	0.1	1.2	0.2	0.1	0.12
VS-17			0.1	0.12	1.1	0.4	0.8	0.06	0.1	0.11
Annual Average	<0.2	<0.2	0.2	0.2	0.5	0.2	0.8	0.2	0.2	0.2

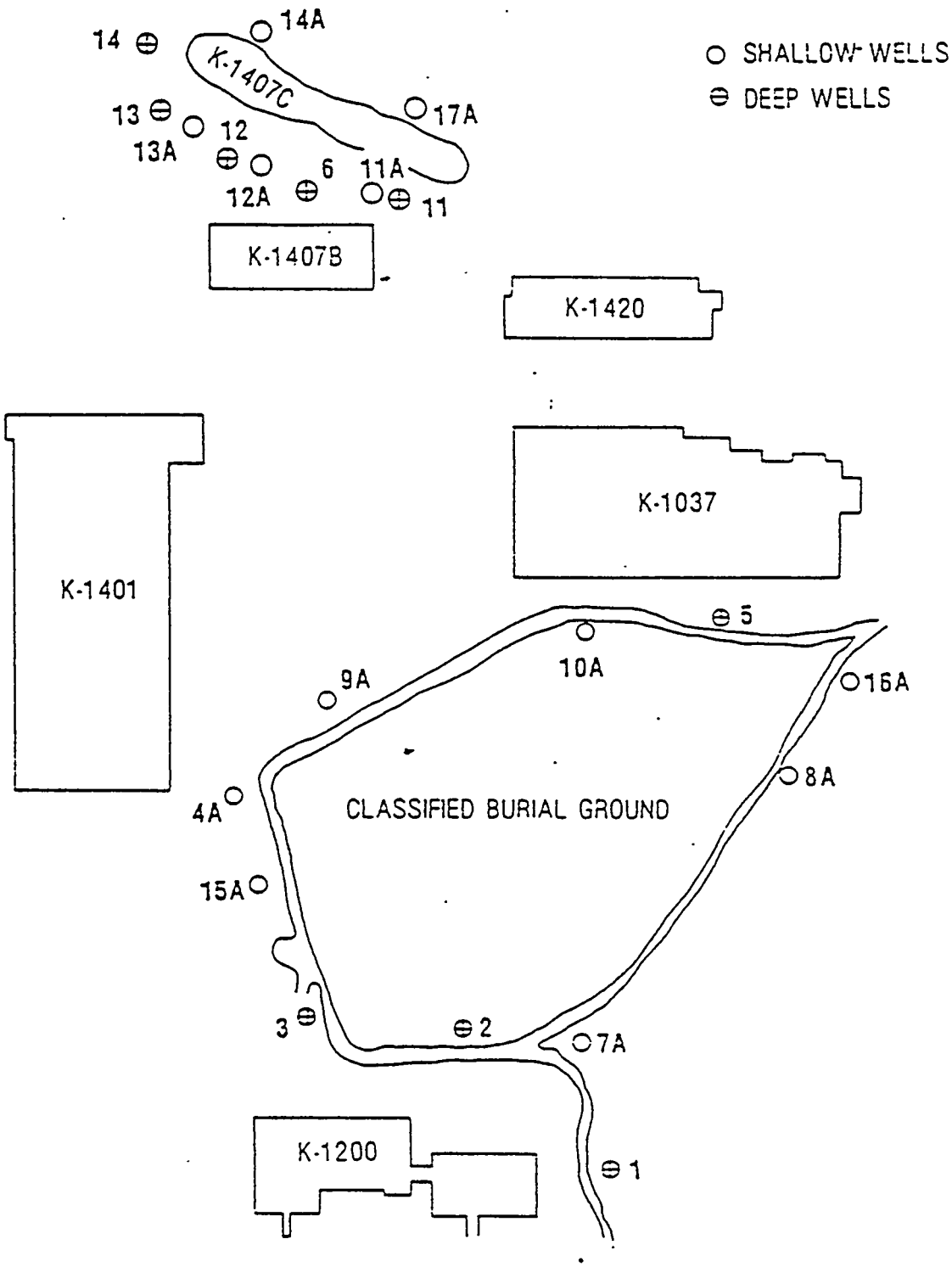
* In 1982, the number of sampling locations were reduced.

Groundwater Uranium Concentration*
10^{-8} µCi/mL

	1979	1980	1981	1982	1983
#1	<0.067	<0.067	<0.067	0.134	0.067
#2	<0.067	<0.067	0.134	0.067	0.201
#3	<0.067	<0.067	<0.067	<0.067	0.134
#4A				0.067	0.738
#5	<0.067	<0.067	<0.067	<0.067	0.201
#6	0.134	0.201	0.134	0.268	0.335
#7A				0.134	0.268
#8A				<0.067	0.536
#9A				0.201	0.536
#10A				0.201	0.402
#11				0.134	0.268
#11A				0.671	0.201
#12				<0.067	<0.067
#12A				0.469	<0.067
#13				0.067	<0.067
#13A				0.067	0.067
#14				0.201	<0.067
#14A				0.067	<0.067
#15A				<0.067	0.201
#16A				0.402	0.671
#17A				0.201	<0.067

* Assumed activity for natural uranium 1.49×10^6 gm/Ci

ORGDP
GROUNDWATER MONITORING WELLS

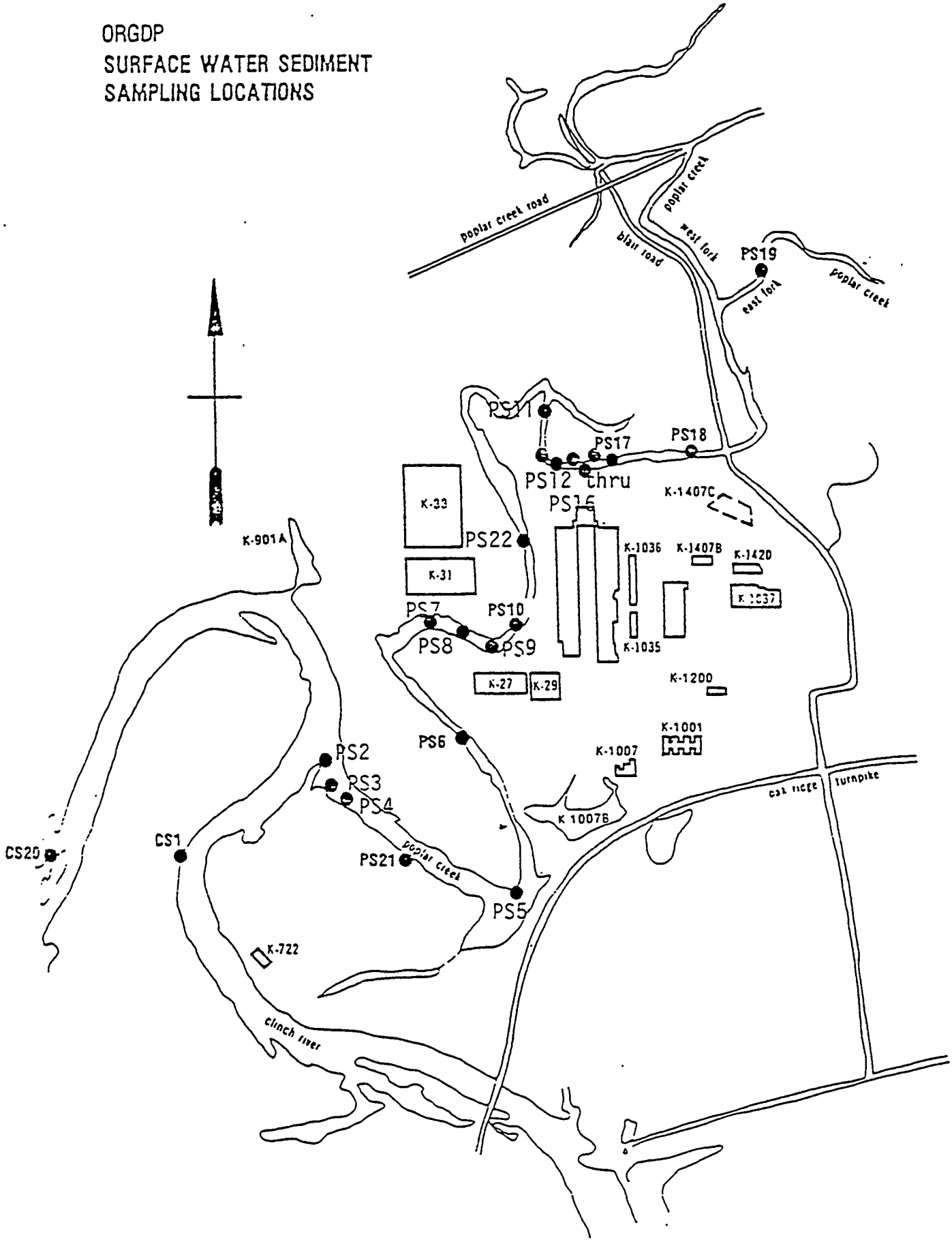


ORGDP GROUNDWATER MONITORING WELL LOCATIONS

Uranium in Stream Sediments
(µg/g)

	1976	1977	1978*	1979	1980	1981	1982*	1983
CS-1	0.4	2.1	16	2	1	1	1	4
PS-2	3.4	10.4	15	17	8	7		
PS-3	4.1	10.8						
PS-4	8.6	15.9						
PS-5	11.1	4.9	9	5	6	6		
PS-6	11.6	38.5	14	14	18	11	6	9
PS-7	59.5	4.5						
PS-8	6.1	5.3						
PS-9	17.8	22.6	4	6	4	3		
PS-10	18.2	4.9	21	4	17	18	10	9
PS-11	2.4	9.5						
PS-12	4.8	4.5	17	17	4	9		
PS-13	23.4	5.9						
PS-14	6.3	20.9						
PS-15	12.6	8.1	95	14	31	31		
PS-16	62.1	42.0						
PS-17	4.5	90.8	12	181	13	13	59	65
PS-18		12.1	6	6	4	6	13	9
PS-19		15.3	9	17	9	12	10	13
PS-21			13	7	7	1	8	13
PS-22			10	12	8	7		
CS-20		1.4	8	1	1	11	1	1

* In 1978 and again in 1982, the number of stream-sediment sampling locations was reduced.



OAK RIDGE GASEOUS DIFFUSION PLANT SEDIMENT SAMPLING LOCATIONS

Y-12 PLANT
AIRBORNE URANIUM EMISSIONS

Year	Uranium Measured (Curies)*
1956	0.20
1957	0.20
1958	0.25
1959	0.35
1960	0.45
1961	0.45
1962	0.50
1963	0.70
1964	0.60
1965	0.40
1966	0.45
1967	0.45
1968	0.35
1969	0.35
1970	0.40
1971	0.05
1972	0.01
1973	0.01
1974	0.09
1975	0.11
1976	0.11
1977	0.06
1978	0.01
1979	0.06
1980	0.16
1981	0.12
1982	0.11
1983	0.12
Total Measured	7.2
Estimated	1.1
TOTAL MEASURED AND ESTIMATED	8.3

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* Uranium measured is given in curies for each year and is based on monitoring results (principally for enriched uranium) and/or accountability data. Estimated quantities are provided for nonmonitored sources. The total of 8.3 curies is equivalent to approxi-

Y-12 PLANT
LIQUID URANIUM EFFLUENTS

Year	Uranium Measured (Curies)*
1954	0.71
1955	0.62
1956	2.26
1957	5.65
1958	5.85
1959	5.15
1960	4.55
1961	2.00
1962	0.86
1963	0.82
1964	4.42
1965	5.91
1966	5.34
1967	10.20
1968	11.75
1969	2.80
1970	5.88
1971	2.37
1972	2.03
1973	0.74
1974	1.04
1975	1.09
1976	0.91
1977	0.50
1978	0.27
1979	0.24
1980	0.10
1981	0.45
1982	0.56
1983	0.14
TOTAL	85.21

* Uranium measured is given in curies for each year (Ci/yr) and is based on monitoring results and/or accountability data. The total of 85.21 curies is equivalent to approximately 280,000 pounds (127,000 kg) of uranium.

Y-12 Plant
Uranium Contained in Solid Waste Buried on Site

Year	Uranium Buried (Curies)*
1954	<0.1
1955	<0.1
1956	12
1957	52
1958	74
1959	120
1960	120
1961	750
1962	150
1963	100
1964	320
1965	190
1966	650
1967	460
1968	140
1969	260
1970	330
1971	390
1972	530
1973	340
1974	460
1975	230
1976	180
1977	150
1978	210
1979	230
1980	790
1981	490
1982	350
1983	390
TOTAL	8,468

* Total uranium contained in solid waste buried on site is given in curies for each year and is based on accountability data. The total of 8,468 curies is equivalent to approximately 52,000,000 pounds (23,000,000 kg) of uranium.

Y-12 Plant Average Uranium Concentration Data from Area Air Monitoring Stations

(Average Gross Alpha, $x10^{-15}$ μCi/mL)

	Station*						
Year	HP-31	HP-32	HP-39	HP-40**	HP-41**	HP-37	HP-55
1966	6	7	6			4	3
1967	3	5	5			3	3
1968	2	2	2			2	1
1969	2	2	2			2	1
1970	1	3	1			1	1
1971	<1	<2	<1			<1	<1
1972	2	3	2			2	2
1973	1.7	2.6	1.8			1.4	1.9
1974	1.3	1.6	1.3			1.0	1.3
1975	1.0	1.4	1.2			1.0	1.1
1976	1.1	1.7	1.4			0.9	<0.9
1977	0.9	1.2	1.1			<1.0	0.9
1978	1.1	1.4	1.1			0.9	<0.9
1979	1.1	1.4	1.2			0.9	0.7
1980	0.9	1.1	0.9			0.9	1.5
1981	0.79	1.1	0.84			0.92	1.3
1982	0.92	1.1	0.86			0.78	1.1
1983	0.93	1.4	0.98	2.2	2.0	0.66	1.2

* See Figures 1 and 2 for location of monitoring stations. Station HP-31, 32, 39, 40, and 41 are related to the Y-12 Plant. Stations HP-37 and 55 are background stations.

** Stations HP-40 and HP-41 were started in 1983.

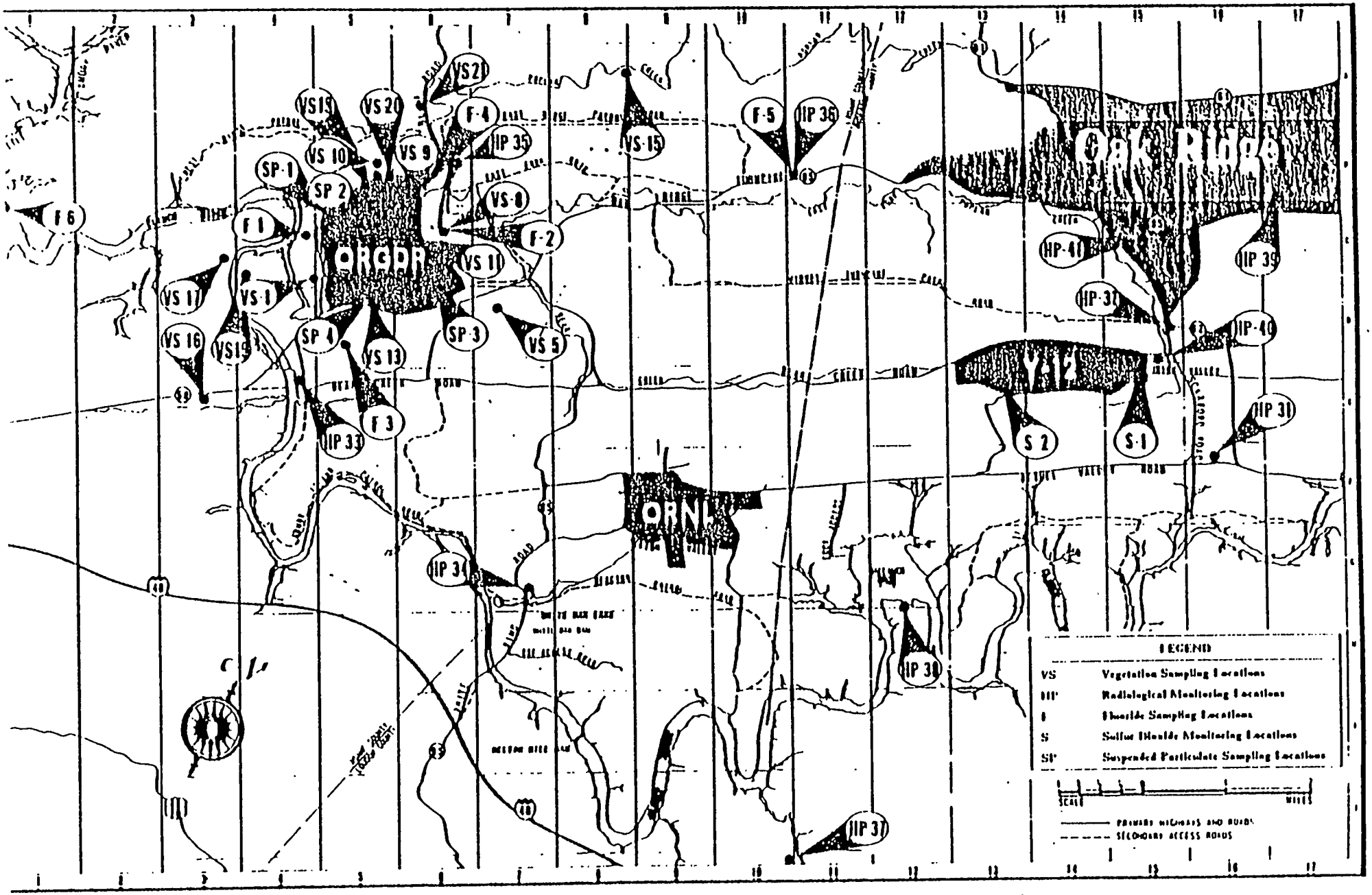
Y-12 Plant Average Uranium Concentration Data from Area Air Monitoring Stations as Percent of Applicable DOE Concentration Guides

Year	Station* HP-31	HP-32	HP-39	HP-40**	HP-41**	HP-37	HP-55	DOE Conc. Guide $\times 10^{-15}$ µCi/mL
1966	0.30	0.35	0.30			0.20	0.15	2000
1967	0.10	0.20	0.15			0.15	0.15	
1968	0.10	0.10	0.10			0.10	0.05	
1969	0.10	0.10	0.10			0.10	0.05	
1970	0.05	0.15	0.05			0.05	0.05	
1971	<0.05	<0.1	<0.05			<0.05	<0.05	
1972	0.1	0.15	0.1			0.1	0.1	
1973	0.04	0.07	0.05			0.04	0.05	4000
1974	0.03	0.04	0.03			0.03	0.03	
1975	0.03	0.04	0.03			0.03	0.03	
1976	0.03	0.04	0.04			0.02	<0.02	
1977	0.02	0.03	0.03			<0.03	0.02	
1978	0.03	0.04	0.03			0.02	<0.02	
1979	0.03	0.03	0.03			0.02	0.02	
1980	0.02	0.03	0.02			0.02	0.04	
1981	0.02	0.03	0.02			0.02	0.03	
1982	0.02	0.03	0.02			0.02	0.03	
1983	0.02	0.03	0.02	0.05	0.05	0.02	0.03	

* See Figures 1 and 2 for location of monitoring stations. Stations HP-31, 32, 39, 40, and 41 are related to the Y-12 Plant. Stations HP-37 and HP-55 are background stations.

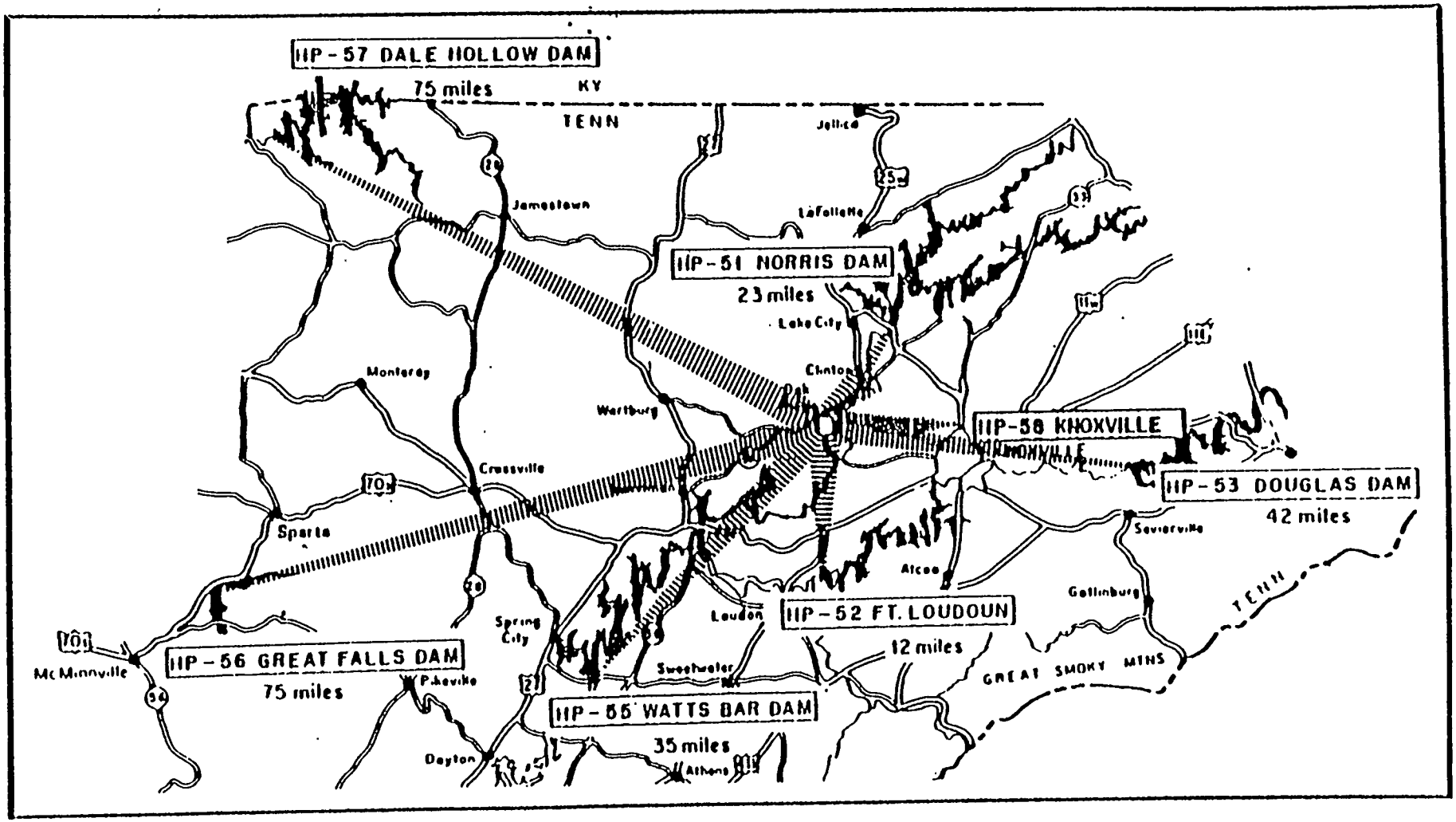
** Stations HP-40 and HP-41 were started in 1983.

*** DOE concentration guides are listed in Appendix B, Table 2. The value of 4000 x 10^{-15} µCi/mL is the lowest limit specified for uranium. Prior to 1973 a different definition of the curie was used, resulting in a different concentration guide.



AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

ORNL DWG 66 17302



REMOTE AIR MONITORING LOCATIONS

Y-12 PLANT URANIUM IN SOIL DATA
(pCi/g)

Year	Station* HP-31	HP-32	HP-39	HP-40**	HP-41**	HP-37	HP-55***
1971	0.11	0.07	0.63			0.14	
1972	0.25	0.47	0.48			0.11	
1973	0.64	0.77	0.28			0.16	
1974	0.81	1.17	1.13			0.99	
1975	1.80	1.70	0.59			0.26	
1976	1.42	1.09	0.55			N/A	0.55
1977	0.79	3.41	1.99			0.51	0.88
1978	0.84	1.63	0.96			0.49	0.79
1979	0.64	2.31	2.03			0.69	0.78
1980	1.31	1.92	1.15			1.01	0.72
1981	1.05	2.23	1.86			0.52	1.14
1982	0.27	0.35	0.38			0.04	0.04
1983	0.98	2.65	1.38	8.76	0.69	0.72	0.67

* See Figures 1 and 2 for location of monitoring stations. Stations HP-31, 32, 39, 40, and 41 are related to the Y-12 Plant. Stations HP-37 and HP-55 are background stations.
** Stations HP-40 and HP-41 were started in 1983.
*** Station HP-55 was established in 1955.
N/A=Not Available

Y-12 Plant Average Uranium Concentration Data for
Surface Water Monitoring Stations

($x10^{-8}$ μCi/mL)

Year	Station E-1*	B-1**	C-3***
1971	24	23	
1972	27	21	
1973	8.5	3.5	<0.2
1974	6.3	5.6	0.5
1975	6.3	5.0	0.3
1976	4.0	6.8	0.5
1977	2.3	2.9	0.3
1978	1.1	1.8	<0.1
1979	1.0	2.6	<0.2
1980	5.2	1.8	<0.09
1981	4.1	3.6	<0.1
1982	2.1	4.1	<0.13
1983	2.9	3.0	<0.17

* East Fork Poplar Creek Station
** Bear Creek Station
*** Clinch River Station (background)

Y-12 Plant Average Uranium Concentration Data for Surface Water Monitoring Stations as Percent of Applicable DOE Concentration Guides

	Station			
Year	E-1[3]	B-1[4]	C-3[5]	DOE Conc. Guide[2] $\times 10^{-8}$ (μCi/mL)
1971	1.2	1.2		2000
1972	1.4	1.1		
1973	0.3	0.1	<0.1	3000
1974	0.2	0.2	<0.1	
1975	0.2	0.2	<0.1	
1976	0.1	0.2	<0.1	
1977	<0.1	<0.1	<0.1	
1978	<0.1	<0.1	<0.1	
1979	<0.1	<0.1	<0.1	
1980	0.2	0.1	<0.1	
1981[1]	6.8	6.0	<0.2	60
1982[1]	3.5	6.8	<0.2	
1983[1]	4.8	5.0	<0.3	

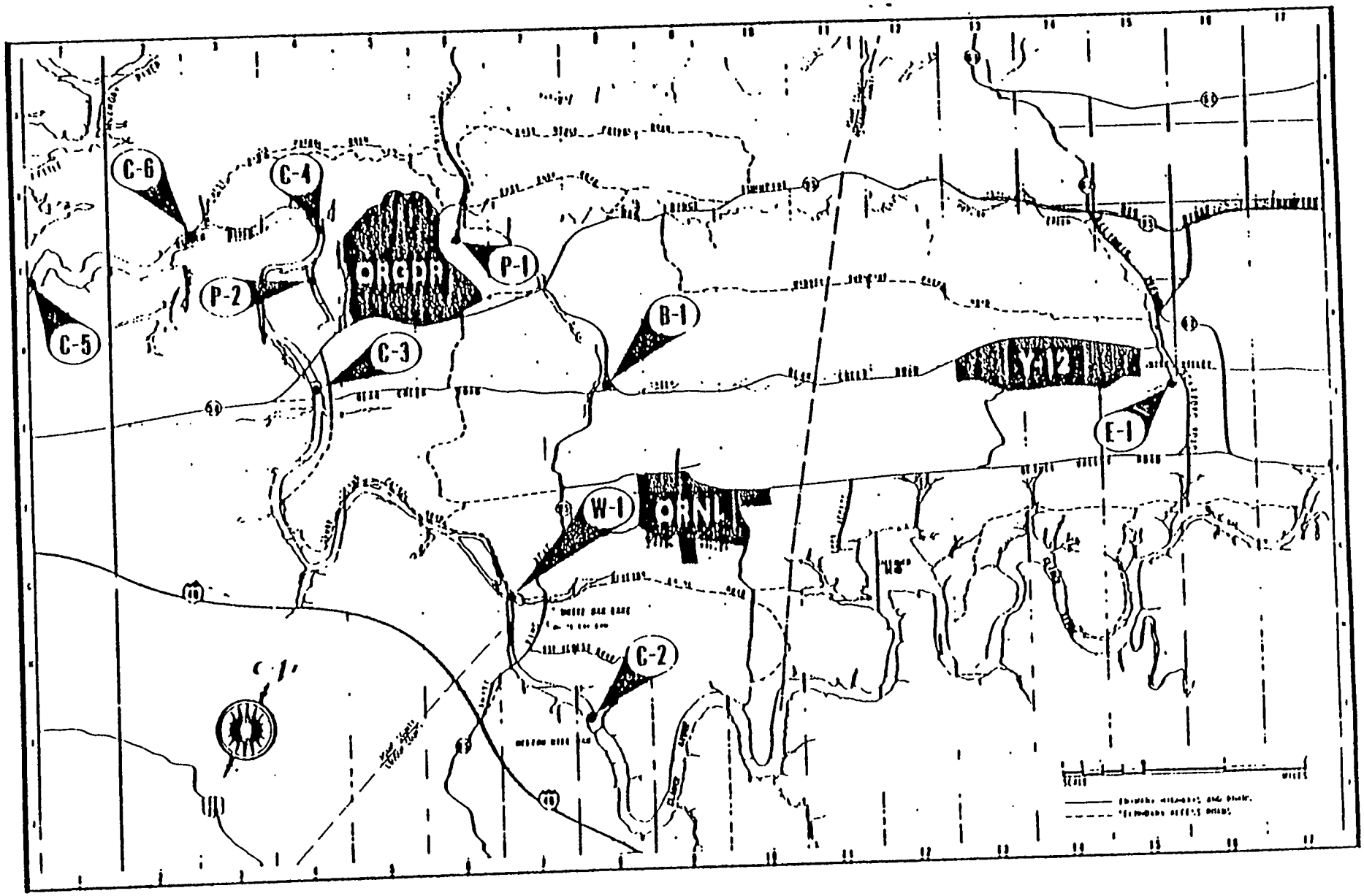
[1] For years 1981-1983 values for Stations E-1 and B-1 are a higher percentage of the DOE concentration due to a reduction in the guide.

[2] DOE concentration guide is listed in Appendix B, Table 4. The value of 60×10^{-8} μCi/mL is the lowest limit specified for uranium. Prior to 1973 a different definition of the curie was used, resulting in a different concentration guide.

[3] East Fork Poplar Creek Station

[4] Bear Creek Station

[5] Clinch River Station (background)



STREAM MONITORING LOCATIONS

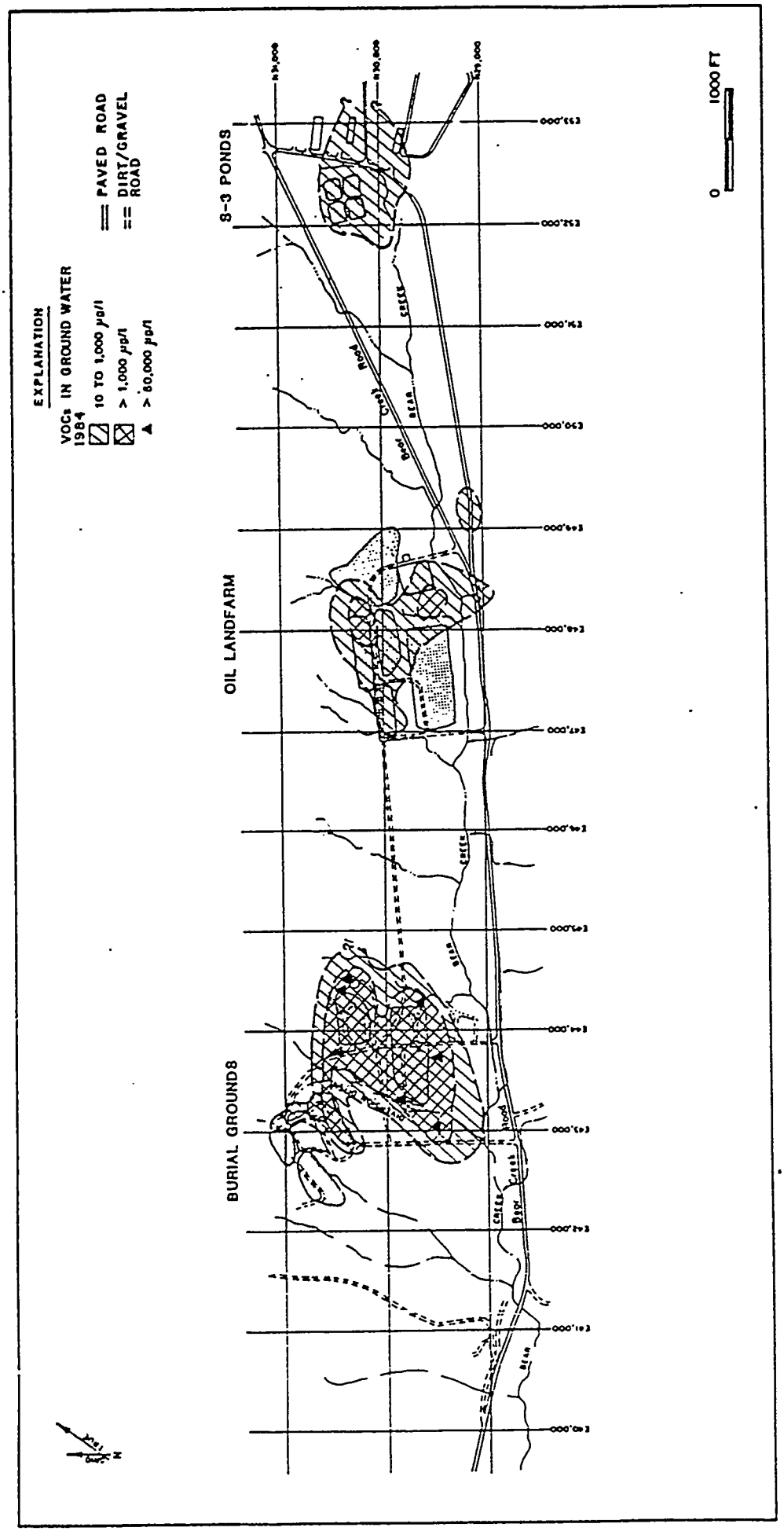


Figure 8-1. APPROXIMATE AREAS OF VOC CONTAMINATION IN GROUND WATER.

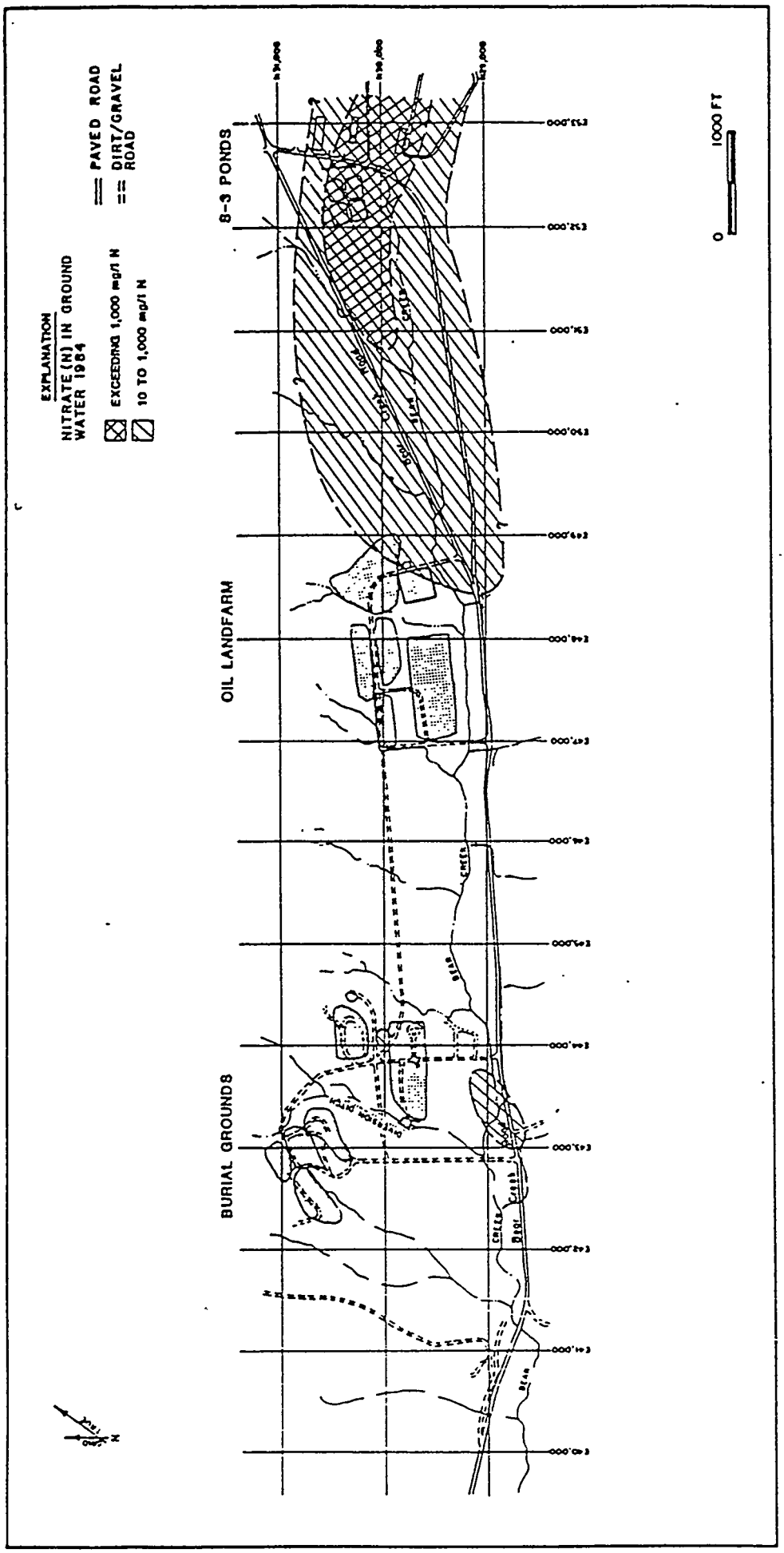


Figure 8-2. APPROXIMATE AREAS OF NITRATE CONTAMINATION IN GROUND WATER.

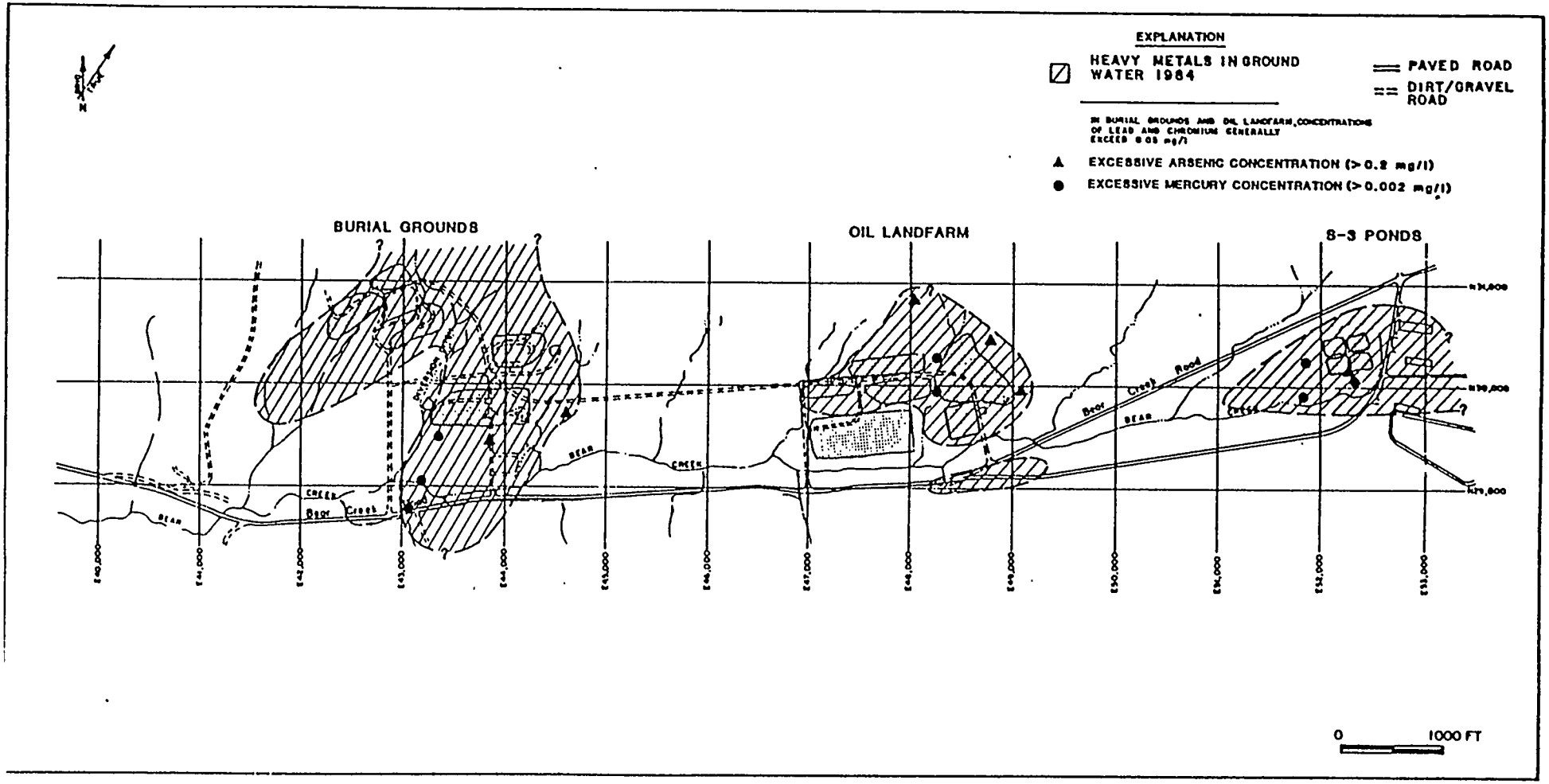


Figure 8-3 APPROXIMATE AREAS OF HEAVY METALS CONTAMINATION IN GROUND WATER.

Oak Ridge Soil Uranium *

Sewer-Line Beltway	2.8 - 38 pci/g
East Fork Poplar Creek Floodplain (general)	3 - 44 pci/g
East Fork Poplar Creek Floodplain (isolated areas)**	13.2 - 146 pci/g
NRD Guideline for Unrestricted Areas	30 - 35 pci/g

* Data Collected by ORAU

** Parcel 564 and ATDL (DOE property)

SCRAP YARD SOIL

SCREENING SAMPLE RESULTS

Parameter	# of Samples	Range (ppm)
Uranium*	19	16 - 600
PCB**	19	4.3 - 380
Mercury***	238	1.0 - 6700

* NRC Guideline 44-51 ppm (natural U).

** EPA Standard 50 ppm.

*** State Guideline 12 ppm.